

M-3, M-23A, M-23B Electric Switch Machines with Permanent Magnet Motor

ASTS USA Part No.
N451160-xxxx
N416001-xx
N416002-xx

- **Installation**
- **Operation**
- **Troubleshooting**

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1. GENERAL INFORMATION

1.1. Introduction

This service manual covers the M-3, M-23A, and M-23B electric switch machines with permanent magnet motors. Mechanically and functionally, there are no major differences between these machines and M-3, M-23A, and M-23B machines with field wound motors. The difference is the motor itself and the wiring associated with it. For permanent magnet motor replacement on existing installations, the machine can be wired for five (5)-wire control. On new installations, the machine is wired for three (3)-wire and two (2)-wire control. This is covered in more detail in later sections of this manual. For ALSTOM/GRS replacement machines, the switch machine is wired for two (2)-wire control (See Section 7).

NOTE

For information on the Electronic Circuit Controller upgrade for the M-3, M-23A, and M-23B machines, refer to service Manual SM 6263A.

1.2. Description

The M-3, M-23A, and M-23B machines consist essentially of a motor, a gear train, cam arrangement for operating the switch and the locking, and circuit controller that includes a point detector (with latchout device). They all use the same base casting and are interchangeable as to mounting and connections in a switch layout, except the additional height of the M-23A and M-23B machines (compared to the M-3 machine), may affect clearance (see dimensions in Figure 2-3 and Figure 2-4). Typical applications are shown in Figure 1-1 and Figure 1-2.

The M-3 machine has no facilities for hand operation, except that in an emergency it may be operated by inserting a removable crank. The M-23A and M-23B machines have dual control features that include a selector lever (to permit manual or power operation) and a hand-throw lever; it is this provision which requires a different gearbox. The M-23A and M-23B machines may also be hand operated by applying a ratchet wrench to the friction clutch adjusting nut.

The M-23A machine differs from the M-23B machine in that it uses a different hand-throw pinion, which affects the hand-throw locking. Power operation is the same in both machines. In the M-23A machine, operation by the hand-throw lever gives the same mechanism stroke, including full lock rod protection, as power operation. In the M-23B machine, however, operation by the hand-throw lever does not provide lock rod protection (the slide bar and lock box do not move full stroke).

Motors and gear ratios are available for operating the machines using either 110 or 20 VDC, and may be changed without changing the gearbox. Two gear ratios are available for the low-voltage (20 VDC) machines; one to provide relatively fast operation as used generally, and the other to provide slower operation for use at locations where current requirements must be held to a minimum. A third gear ratio is used with the high-voltage (110 VDC) motors.

General Information

The machines are completely wired at the factory with the internal wiring connected to the main terminal board in the motor compartment. A typical wiring diagram or working drawing is enclosed with each machine when shipped, showing how external connections are to be made to the main terminal board for a particular application. To allow standardized wiring, provision is made in the circuit controller for arranging it to always have certain contacts indicate Normal, regardless of which end of the operating stroke is established as Normal. The internal wiring includes wires for an electric heater that can be added in the circuit controller. An electric heater for the motor compartment is also available.

1.3. Operating Mechanism

The M-3 (see Figure 1-1) and M-23A and M-23B (see Figure 1-2) machines each contain three compartments.

- a. Motor compartment, housing the motor. This compartment also contains the main terminal board and has a wire outlet for the external wiring. The friction clutch of the gear train projects into this compartment.
- b. Gearbox, housing the gear. There are two compartments in the gearbox, one for the spur gear portion of the reduction gearing, and the other for the main crank and worm gear drive. Connection between the spur gears and the worm shaft is through the friction clutch, which projects into the motor compartment as mentioned in paragraph 'a'. The friction clutch protects the mechanism from shock at the end of the stroke or when travel is stopped suddenly by an obstruction in the switch point or by lock rod fouling. The gearbox also houses the mechanism for operation by a hand crank (M-3) or by the dual-control mechanism (M-23A and M-23B).
- c. Circuit controller compartments. This compartment contains the circuit controller, locking features, point detector device, and a separate set of motor cutout contacts which open the motor circuit and may also control a line circuit whenever the hand crank is inserted in the M-3 machine or the selector lever is operated out of its "motor" position in the M-23A and M-23B machines.

In addition to the elements just mentioned, a slide bar runs lengthwise in the base of the machine. It is driven by the main crank and operates the lock box in the circuit controller compartment. Perpendicular to the mechanism and beneath the slide bar is a switch operating bar which also is driven by the main crank and to which the switch operating rod is connected (see Figure 3-1). The point detector rod and lock rods, operated by connections to the switch points, are supported in the circuit controller compartment.

Switch operation, switch locking, and circuit controller operation are all performed by the vertical main crank in the gearbox. The main crank is driven either by the motor or by the hand operation facilities. Refer to Section 3 for detailed operation of the switch machine.

1.4. Specifications

1.4.1. Physical Characteristics

Table 1-1. Physical Characteristics

	M-3	M-23A/M-23B
Length	63-1/2 in.	63-1/2 in.
Width	33 in.	33 in.
Height	10-1/4 in.	14 in.
Weight	810 lb	860 lb

1.4.2. Operating Characteristics

Table 1-2. Operating Characteristics

Voltage*	Time**	Gear Ratio	Clutch Setting
110 VDC	4.5 seconds	189:1	14 amps
110 VDC	8.0 seconds	360:1	10 amps
20 VDC	15 seconds	360:1	23 amps
20 VDC	26/34 seconds	528:1	12 amps

* Voltage at motor terminals.

** Switch over time measured in accordance with AREMA (AAR) Manual Part 12.2.5.
These times will vary depending upon motor terminal voltage and machine operating load and conditions.

1.4.3. Electrical Data

Table 1-3. Electrical Data

Motor Part No.	Motor Voltage
J717216-0301	110 VDC
J717216-0302	20 VDC
J717216-0303	20 VDC
J717216-0501	20 VDC
J717216-0502	20 VDC
J717245-0002	20 VDC
M451161-5701	110 VDC

Heaters work with any switch machine and are dependent on the application:

15W-115 VAC or VDC
15W-115/230 VAC or VDC
15W-24 VDC

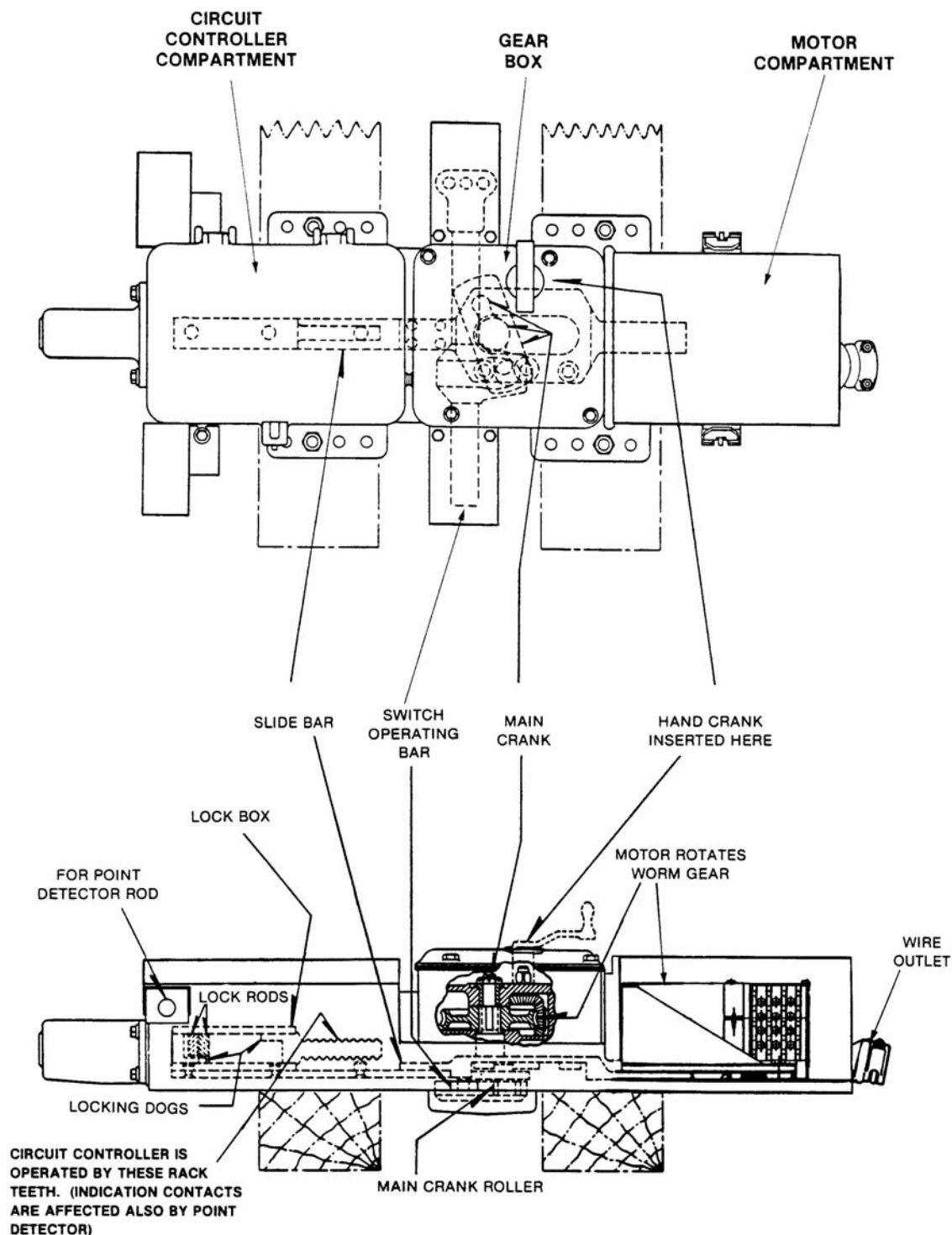
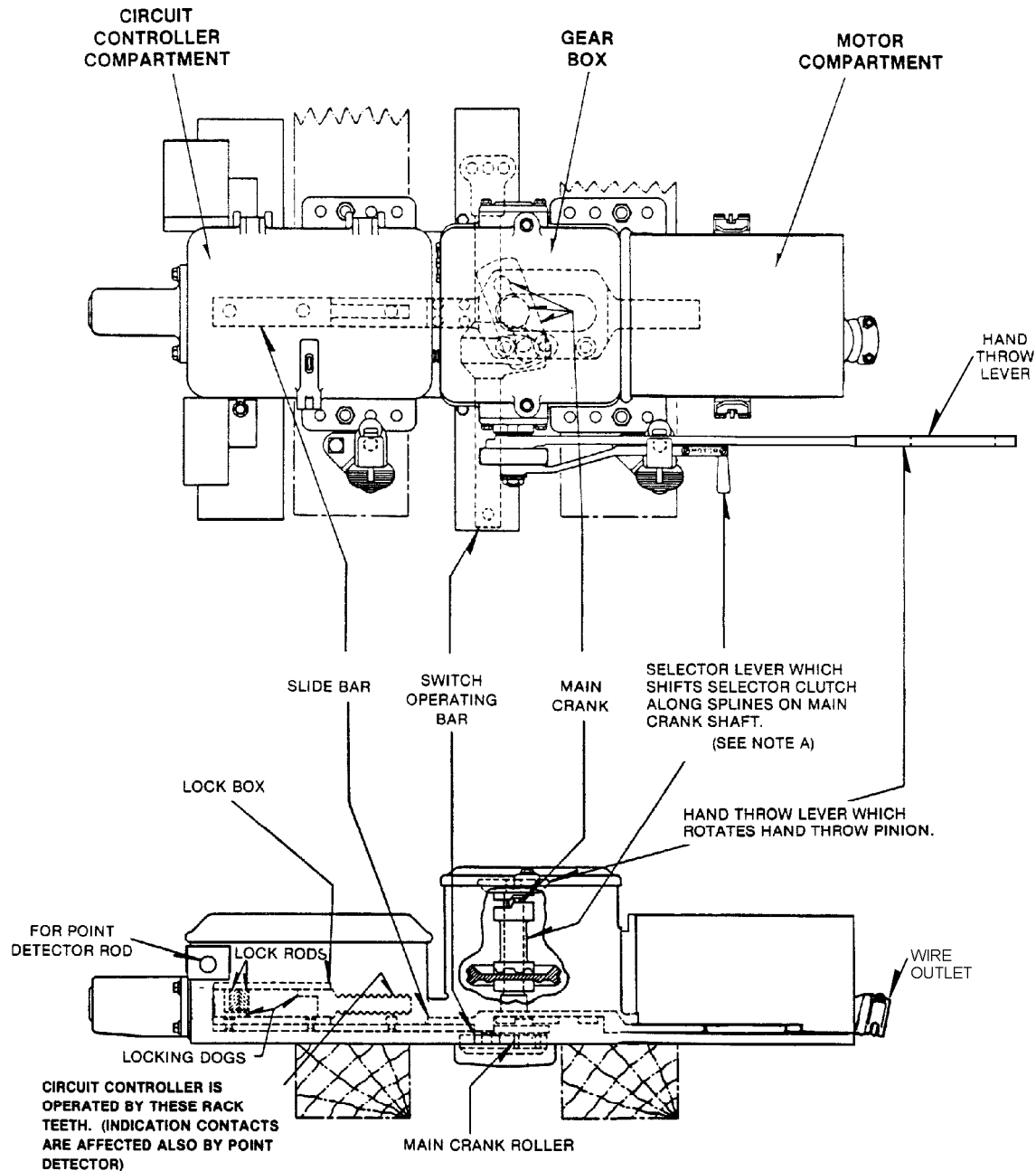


Figure 1-1. M-3 Switch Machine Outline Diagram



NOTE A

CLUTCH OVERALL HEIGHT IS SUCH THAT TOP TOOTH MUST ENGAGE HAND THROW GEAR BEFORE BOTTOM TEETH CAN DISENGAGE WORM GEAR, OR VICE VERSA. THUS, THE MAIN CRANK IS NEVER "FLOATING," BUT AT ALL TIMES IS ENGAGED WITH EITHER THE MOTOR OR THE HAND THROW LEVER.

942.0010.00

Figure 1-2. M-23A and M-23B Switch Machine Outline Diagram



2. INSTALLATION AND ADJUSTMENTS

2.1. General Information

In general, the application of the M-3, M-23A, and M-23B machines is as shown in Figure 2-1 and Figure 2-2, but detail mounting plans approved by the railroad should be followed when installing the machine. Mounting dimensions are shown in Figure 2-3 and Figure 2-4. Switch machines are assembled at the factory to suit particular layouts when sufficient information is provided in the order, but can be changed from right-hand to left-hand or vice versa in the field. Conversion of the M-3 is very simple and no detail instructions are required. Detail instructions for changing the M-23A and M-23B dual-control machines are given in paragraphs 5.4.10 and 5.5.2. After the machine has been properly assembled for the layout, check the following:

- a. Two 3/8" pipe plugs are enclosed in a bag tied within the motor compartment. They are for application to two drain holes located in the cover under the crank case compartment (Z, Figure 5-3 and Figure 5-4) when the machine is in a location where blowing sand or dust is troublesome, but should not be applied unless this condition prevails – and if used should be removed at intervals to drain the compartment, especially prior to freezing weather.
- b. Two other drain plugs (x, Figure 5-3 and Figure 5-4), consisting of slotted head bolts with lock washers, are provided in the circuit controller compartment. These are shipped in place, but not fully tightened. Like the pipe plugs, they should be left applied only at locations where blowing sand or dust is troublesome.

2.2. Mounting

Mount and secure the switch machine on ties according to the layout plans applying to the particular location. Adjust the height of the lever stand so that the selector and hand-throw levers on M-23A and M-23B machines are held in a horizontal position parallel with the top of the gearbox.

2.3. Switch Rod Installation and Adjustment

Connect the switch-operating rod and adjust the rod nuts at the switch basket to obtain the proper pressure at the switch points. Nothing is gained by excessive pressure.

2.4. Lock Rod Installation and Adjustment

With the covers removed and machine at mid-stroke, apply the lock rods. Be sure that the flat plate snow cover is assembled on the track side (where applicable) when applying the lock rods, and that the rods are assembled such that the locking dogs in the lock box will enter the narrow notches first. In some instances it may be necessary to invert the lock box to suit the rod notches, in this case refer to the instructions in paragraph 2.11.1. Preliminary adjustment should be made by setting the nuts so that the narrow notches are nearly centered on the locking dogs at each end of the stroke. (This requires that the M-23B machine be operated by power or by turning the friction clutch housing by applying a ratchet wrench to the clutch adjusting nut with the selector

lever in the MOTOR position and power disconnected.) The upper narrow notch can be seen directly. Index marks are provided on the top surface opposite the notched ends for the lower notch. Make final adjustments in accordance with AREMA Signal Section or railroad instructions.

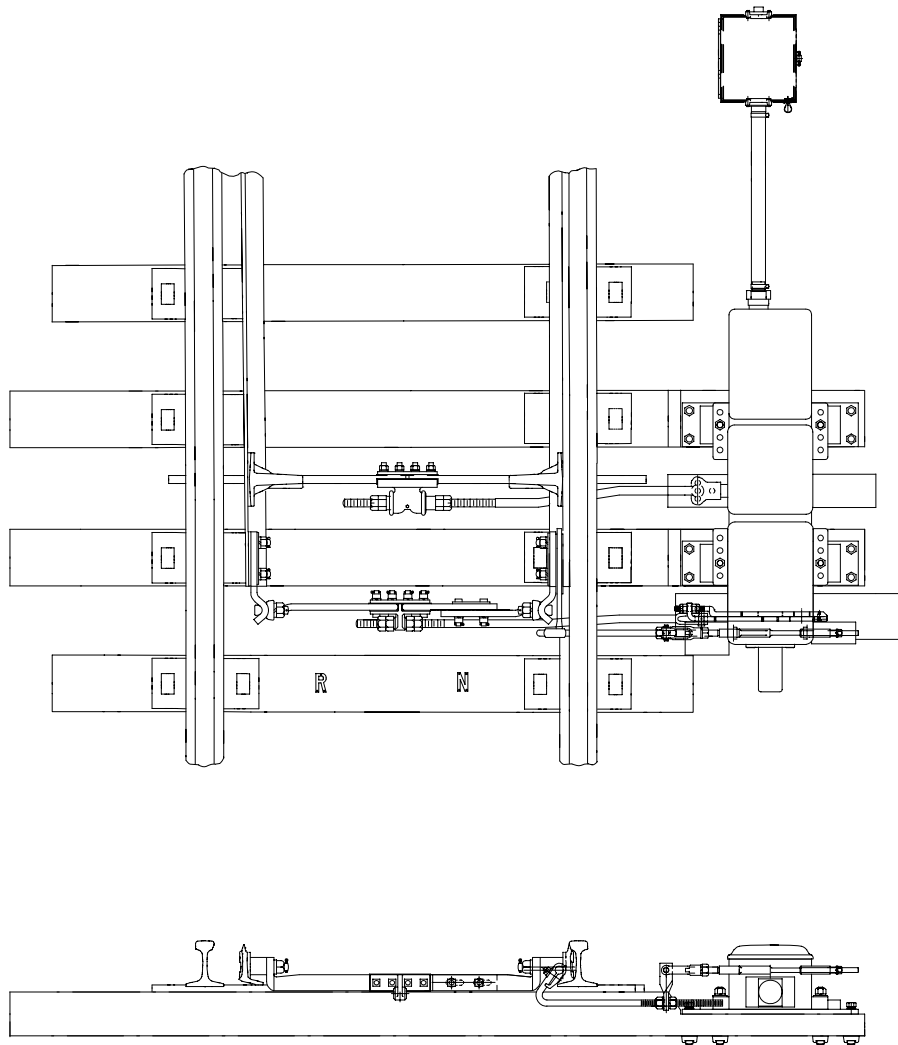


Figure 2-1. Typical M-3 Machine Application

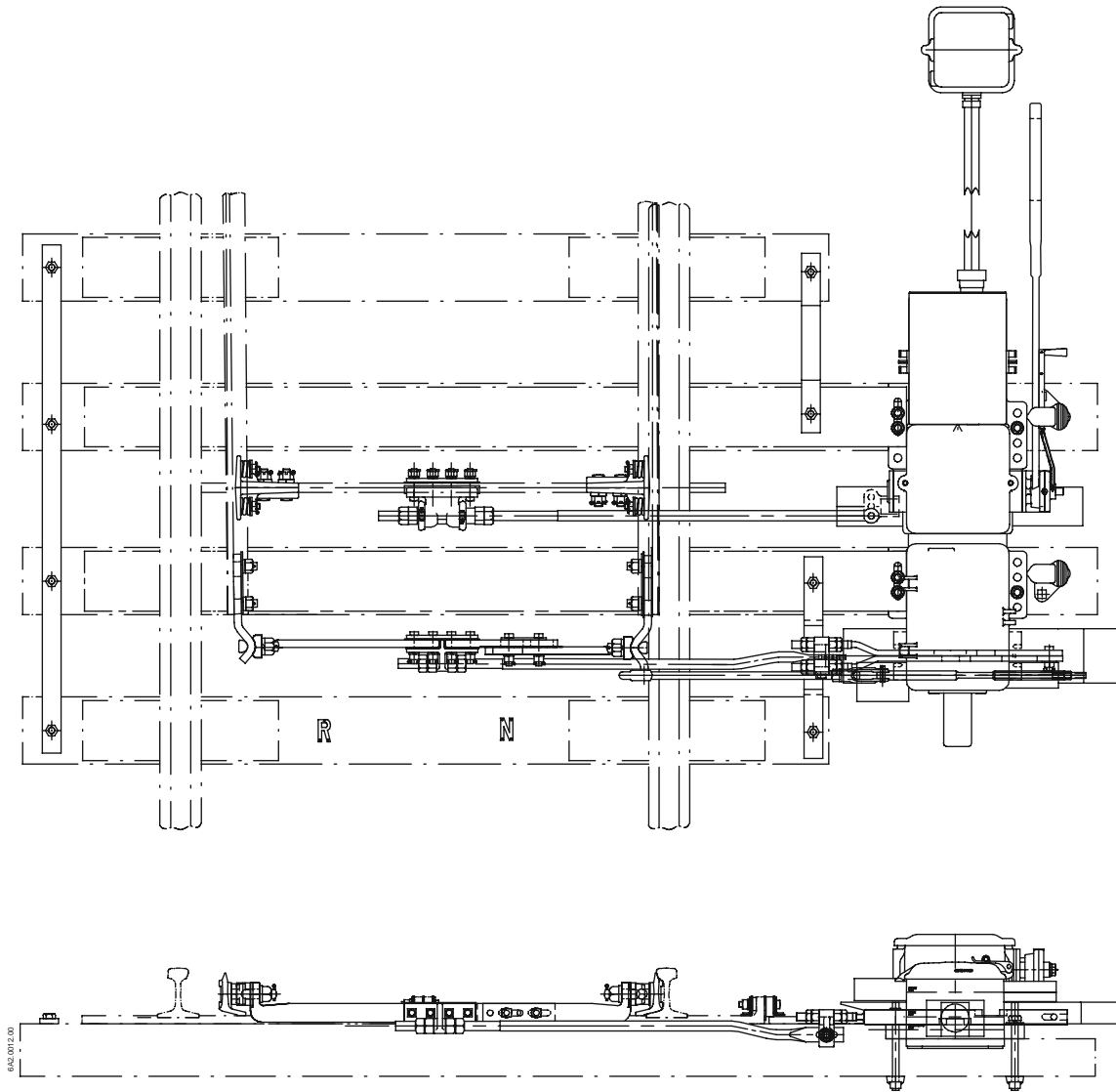


Figure 2-2. Typical M-23A and M-23B Machine Application

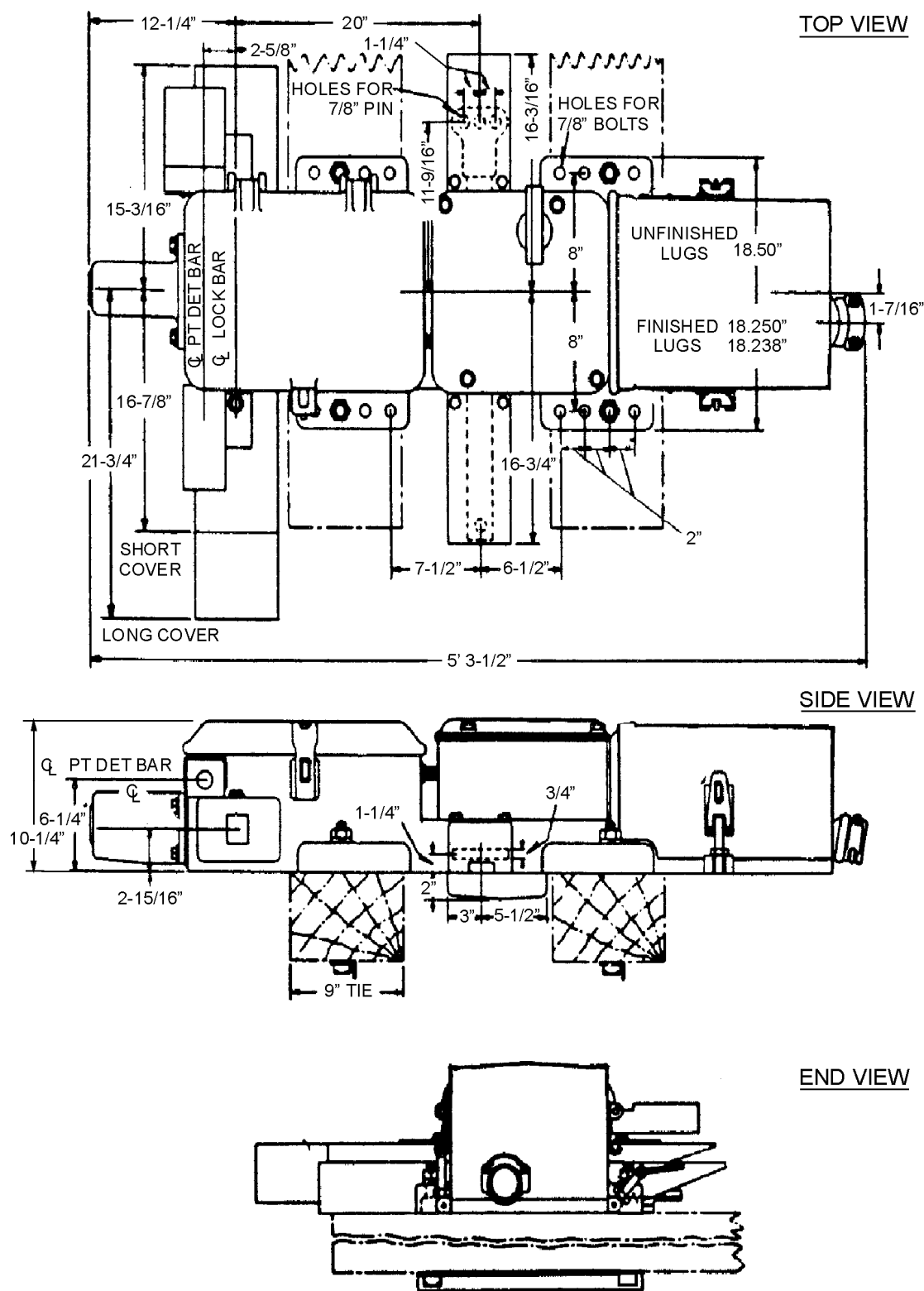


Figure 2-3. Typical M-3 Mounting Plan

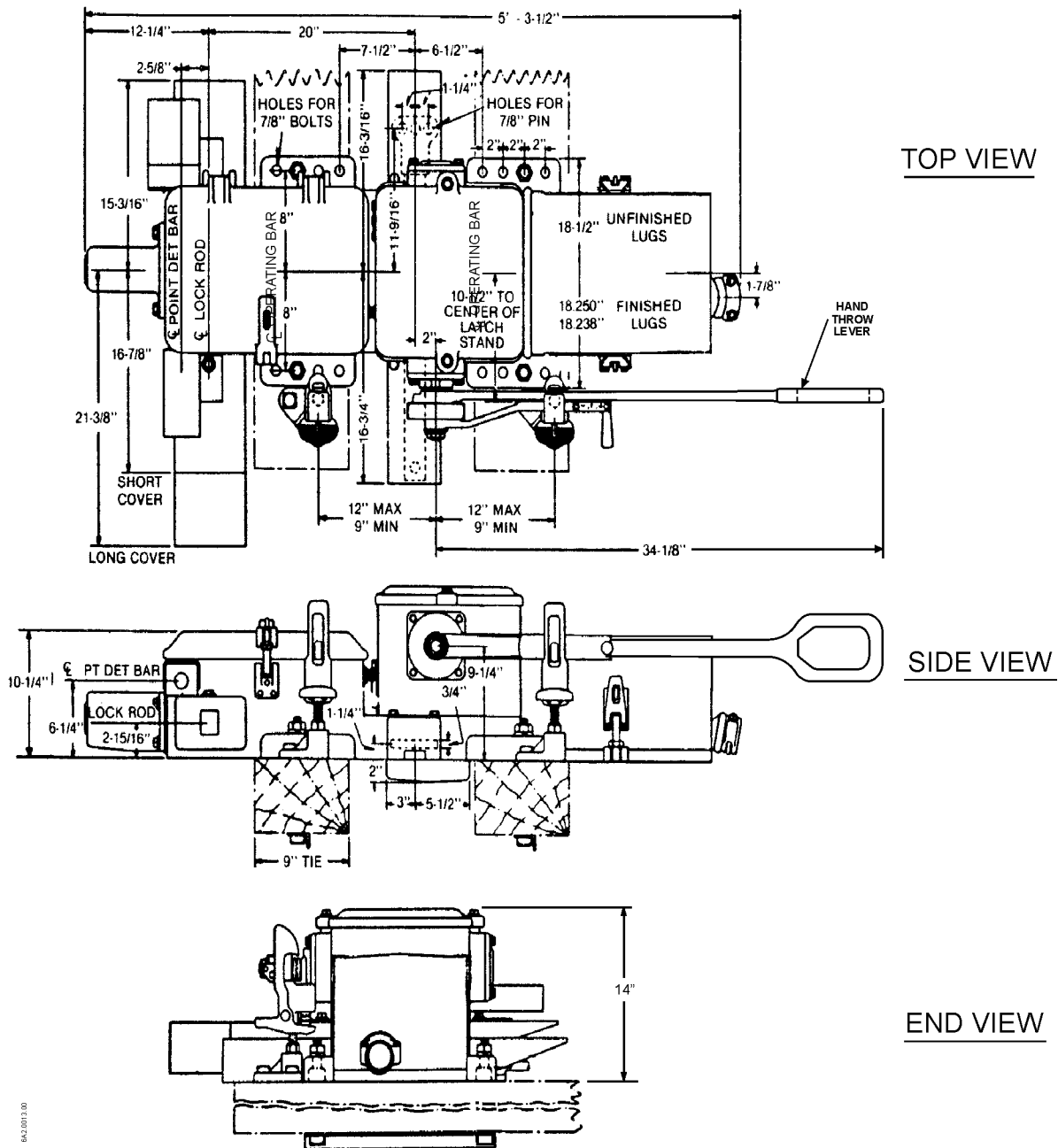


Figure 2-4. Typical M-23A and M-23B Mounting Plan

2.5. Point Detector Bar Installation and Adjustment

Apply the point detector bar (remove shipping closures in the housing) and its connecting rod. Adjust to check switch point opening in accordance with AREMA Signal Section or railroad instructions. When making adjustments, be sure to work first with adjustments for the far switch point, using the nuts on the track end of the point detector bar; then adjust for the near switch point, working at the field end of the point detector bar.

NOTE

The switch-operating rod, point detector rod, and lock rods should be kept in adjustment to meet AREMA Signal Section or railroad specifications. Refer to Service Manual 5453 for a gauge available to check the point detector between periodic obstruction tests.

Check that indication cam N on the left side of machine center line, as viewed from controller end (see Figure 3-5), has its notch up when the machine is in the Normal position, and that indication cam P on the right side has its notch up when the machine is in the reverse position. If not, shift them in accordance with the instructions in Section 2.11.2.

2.6. Lever Stand Adjustment

(M-23A and M-23B machines.) Make a final check of the lever stand adjustment to assure that transfer from power to hand operation can be made under all conditions, as follows:

- a. Remove the gearbox cover so that the action of the selector clutch (see Figure 3-14) and its relation to the hand-throw pinion can be observed as the selector lever is operated from MOTOR to HAND position.
- b. With the hand-throw lever in Normal, operate the machine by power to the Reverse position, then back to the Normal position. Operate the selector lever to HAND. Check that the selector clutch shifts up, engaging the tooth on the bottom of the hand-throw pinion, and check that the hand-throw lever will operate the machine. If the selector clutch fails to shift up full-stroke, readjust the height of the Normal hand-throw lever stand to bring the clutch teeth into proper alignment.
- c. With the hand-throw lever in Reverse, operate the machine by power to the Normal position, then back to the Reverse position. Operate the selector lever to HAND. Check that the selector clutch shifts up, engaging the tooth on the bottom of the hand-throw pinion, and check that the hand-throw lever will operate the machine. If the selector clutch fails to shift up full-stroke, readjust the height of the Reverse hand-throw lever stand to bring the clutch teeth into proper alignment.

- d. With the hand-throw lever in Normal, operate the machine by power to the Reverse position. Operate the selector lever to HAND. The selector clutch should ride against (but not engage) the hand-throw pinion tooth. The selector clutch spring should be compressed, taking up the clearance between the upper and lower spring cups. Now operate the hand-throw lever toward Reverse. The selector clutch should snap up into engagement with the hand-throw pinion just before the hand-throw lever is fully down in the Reverse lever stand. Check that the hand-throw lever will now operate the machine.
- e. With the hand-throw lever in Reverse, operate the machine by power to the Normal position. Operate the selector lever to HAND. The selector clutch should ride against (but not engage) the hand-throw pinion tooth. The selector clutch spring should be compressed, taking up the clearance between the upper and lower spring cups. Now operate the hand throw lever toward Normal. The selector clutch should snap up into engagement with the hand-throw pinion just before the hand-throw lever is fully down in the Normal lever stand. Check that the hand-throw lever will now operate the machine.

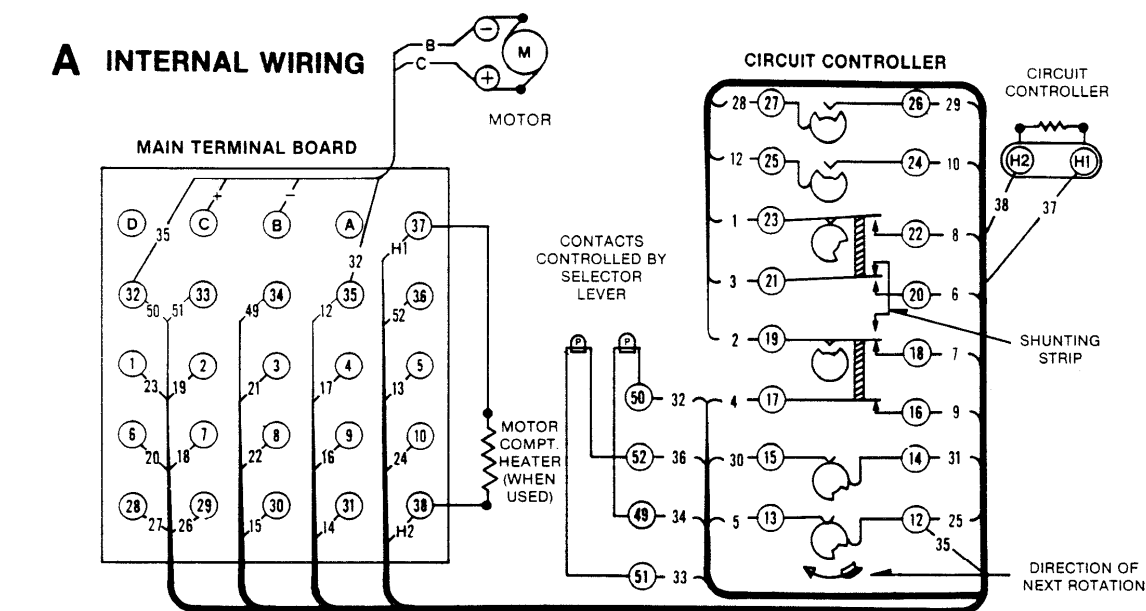
2.7. Electric Connections and Control Wiring

In accordance with all applicable railroad safety and operating standards, connect the external wiring to the terminal board in accordance with the wiring diagram for the particular location.

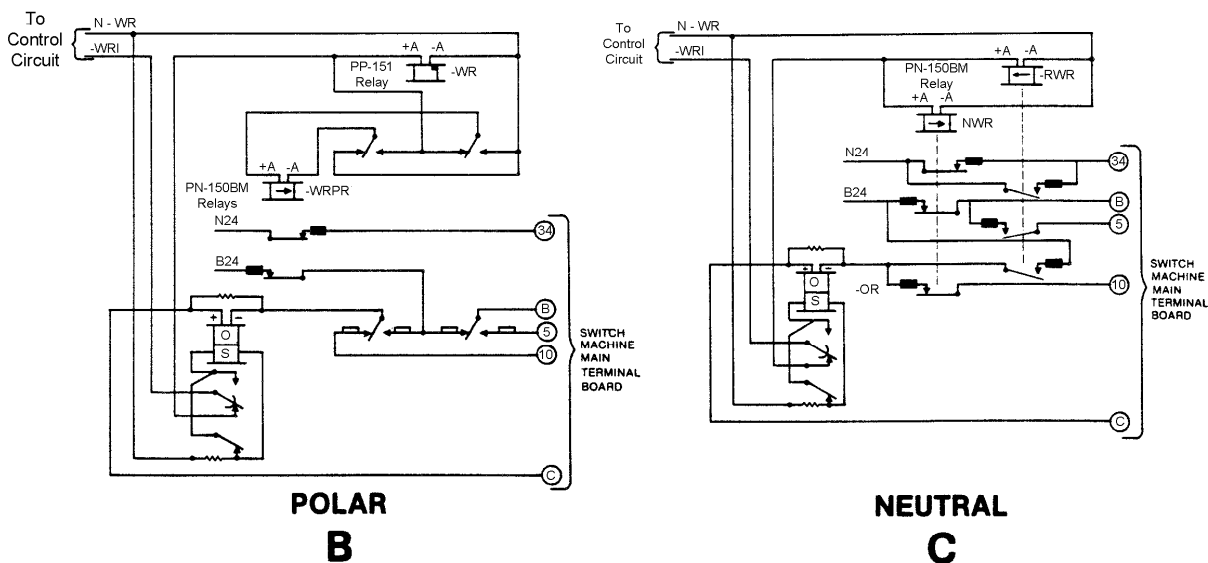
Figure 2-5 shows internal (view A) and control wiring (views B and C) for low-voltage machines using five-wire control, which is intended primarily for permanent magnet motor replacement on existing installations. Figure 2-6 shows internal (view A) and control wiring (views B and C) for low voltage machines using three-wire control, which is intended primarily for new installations. Figure 2-7 (five-wire control) and Figure 2-8 (three-wire control) similarly show internal (view A) and control wiring (views B and C) for high-voltage machines. For ALSTOM/GRS replacement machines (two-wire control), refer to the wiring diagrams in Section 7.

The circuit controller indication cams are shown for a switch having the right-hand point normally closed and in Normal position. There is no difference due to the side of the track on which the machine is placed.

Figure 2-5 through Figure 2-8 (views B and C) are typical circuits for the control of switch machines using the standard PN-150SO, the PN-150BM and the PP-151 plug-in relays. These typical circuits show wiring of the relays which corresponds to the internal wiring diagrams for standard DC switch machines as applied to single switches.



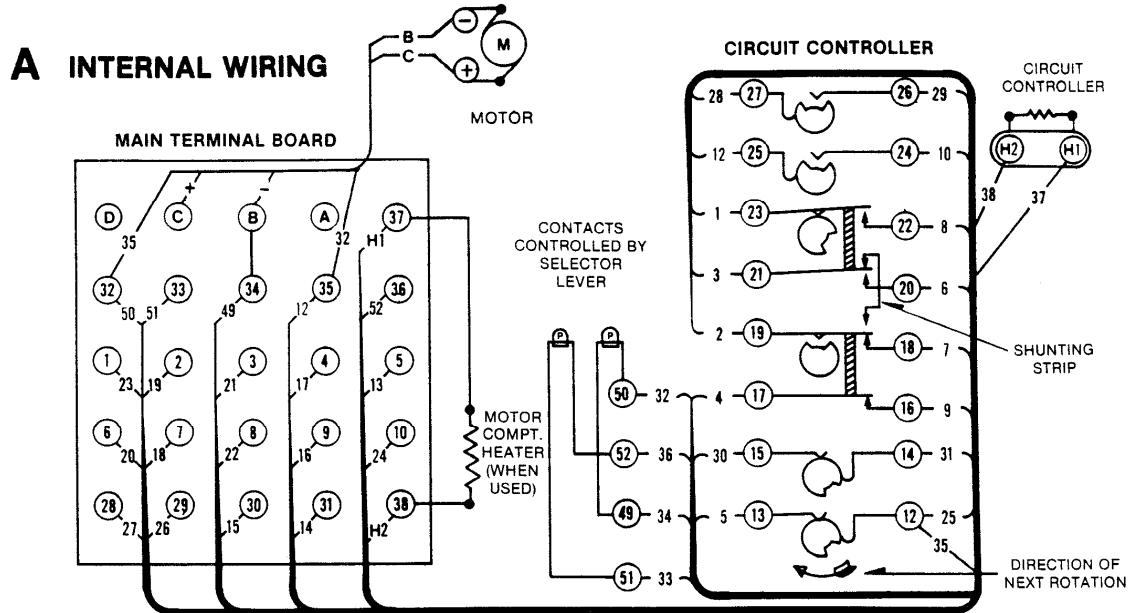
CONTROL WIRING



NOTE: EXTERNAL CONNECTIONS ARE SHOWN TO THE MAIN TERMINAL BOARD FOR A SWITCH HAVING THE RIGHT-HAND POINT NORMALLY CLOSED.

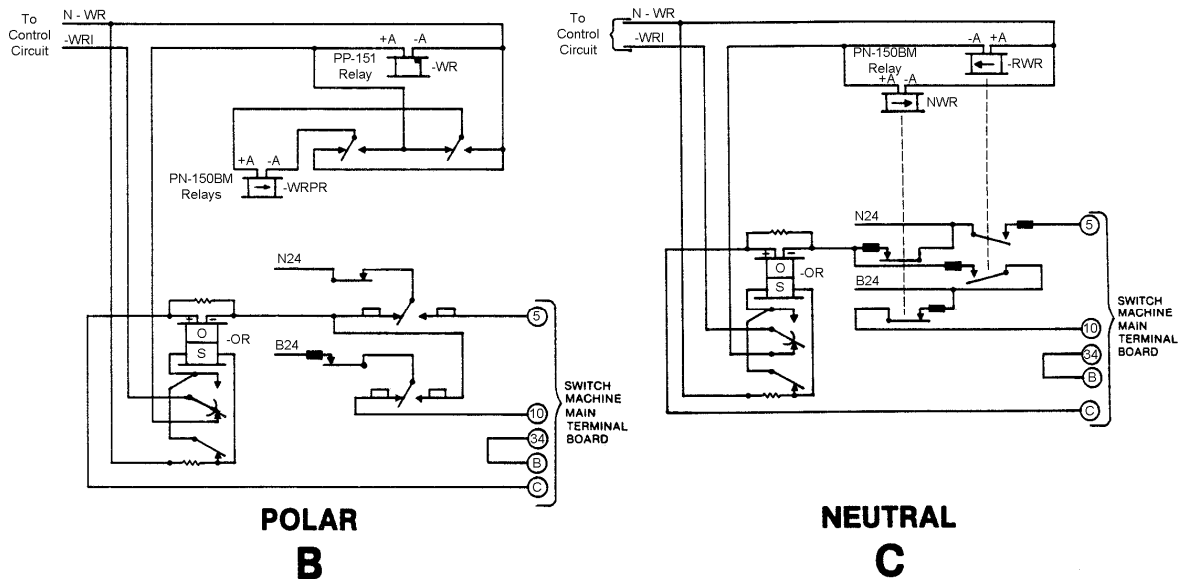
FOR A SWITCH HAVING THE LEFT-HAND POINT NORMALLY CLOSED, INTERCHANGE THE EXTERNAL LEADS TO TERMINALS (B) AND (C) AND TO TERMINALS (5) AND (10) ON THE MAIN TERMINAL BOARD.

Figure 2-5. M-3/M-23 Low Voltage DC Machines, Five (5)-Wire Control



NOTE: NUMBER IN CIRCLE REPRESENTS NUMBER OF TERMINAL. NUMBER NOT IN CIRCLE SHOWS NUMBER OF TERMINAL TO WHICH OTHER END OF WIRE IS CONNECTED.

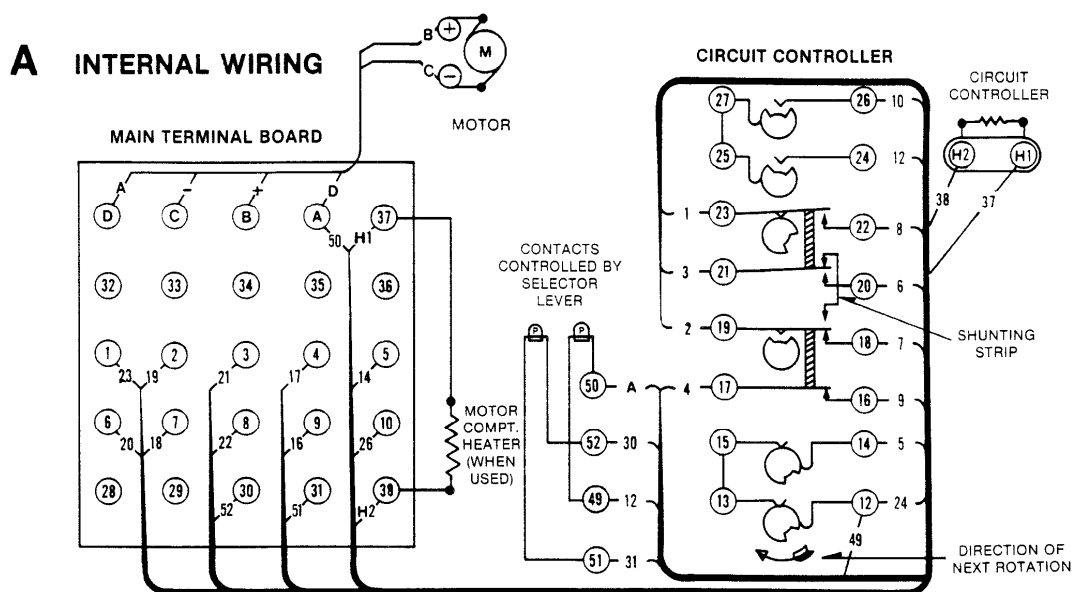
CONTROL WIRING



NOTE: EXTERNAL CONNECTIONS ARE SHOWN TO THE MAIN TERMINAL BOARD FOR A SWITCH HAVING THE RIGHT-HAND POINT NORMALLY CLOSED.

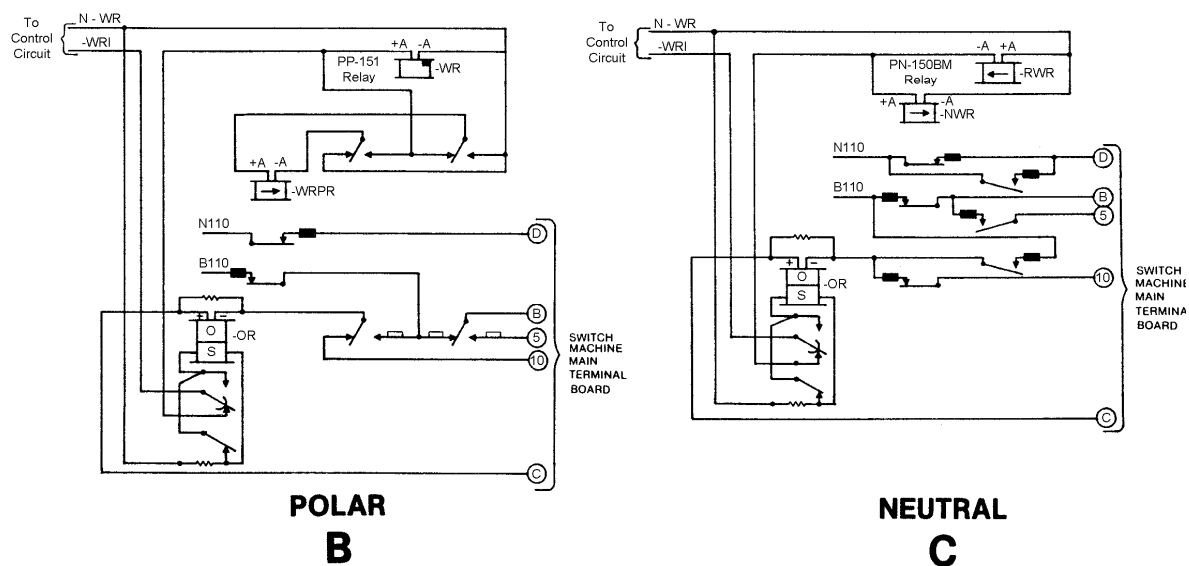
FOR A SWITCH HAVING THE LEFT-HAND POINT NORMALLY CLOSED, INTERCHANGE THE EXTERNAL LEADS TO TERMINALS (5) AND (10) AND TO TERMINALS (B) AND (C) ON THE MAIN TERMINAL BOARD.

Figure 2-6. M-3/M-23 Low Voltage DC Machines, Three (3)-Wire Control



NOTE: NUMBER IN CIRCLE REPRESENTS NUMBER OF TERMINAL. NUMBER NOT IN CIRCLE SHOWS NUMBER OF TERMINAL TO WHICH OTHER END OF WIRE IS CONNECTED.

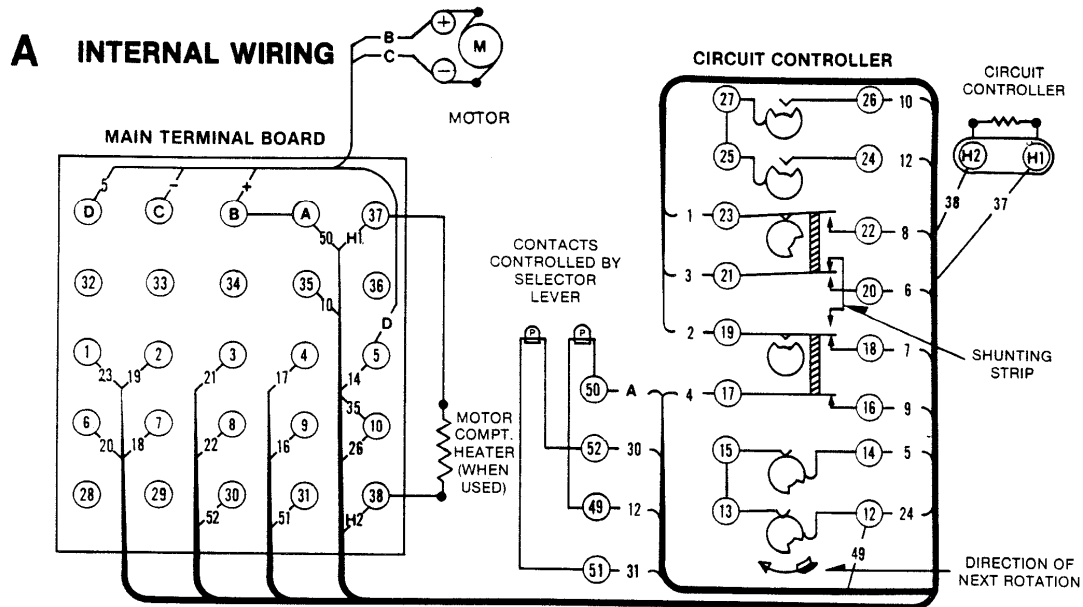
CONTROL WIRING



NOTE: EXTERNAL CONNECTIONS ARE SHOWN TO THE MAIN TERMINAL BOARD FOR A SWITCH HAVING THE RIGHT-HAND POINT NORMALLY CLOSED.

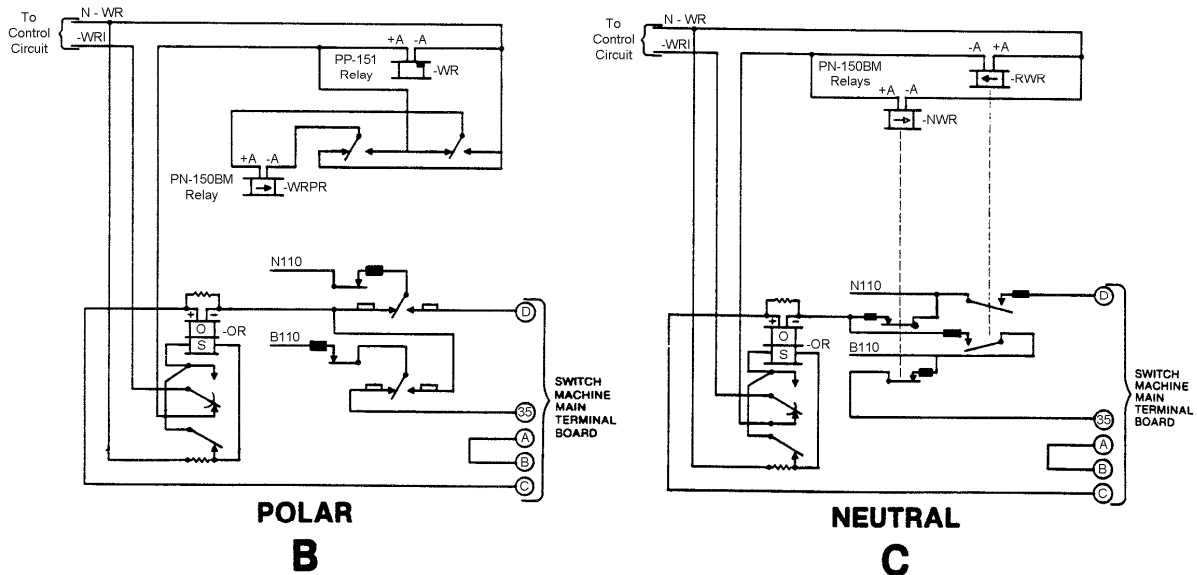
FOR A SWITCH HAVING THE LEFT-HAND POINT NORMALLY CLOSED, INTERCHANGE THE EXTERNAL LEADS TO TERMINALS (B) AND (C) AND TO TERMINALS (5) AND (10) ON THE MAIN TERMINAL BOARD.

Figure 2-7. M-3/M-23 High Voltage DC Machines, Five (5)-Wire Control



NOTE: NUMBER IN CIRCLE REPRESENTS NUMBER OF TERMINAL. NUMBER NOT IN CIRCLE SHOWS NUMBER OF TERMINAL TO WHICH OTHER END OF WIRE IS CONNECTED.

CONTROL WIRING



NOTE: EXTERNAL CONNECTIONS ARE SHOWN TO THE MAIN TERMINAL BOARD FOR A SWITCH HAVING THE RIGHT-HAND POINT NORMALLY CLOSED.

FOR A SWITCH HAVING THE LEFT-HAND POINT NORMALLY CLOSED, INTERCHANGE THE EXTERNAL LEADS TO TERMINALS (35) AND (D) AND TO TERMINALS (B) AND (C) ON THE MAIN TERMINAL BOARD.

Figure 2-8. M-3/M-23 High Voltage DC Machines, Three (3)-Wire Control

Installation and Adjustments

The current style of plug-in switch control relay is the PP-151 used in conjunction with the PN-150BM relay. This is the equivalent of the shelf type DP-25 or the earlier style plug-in type PNP-69. The PP-151 is a magnetic stick relay used for reversing the polarity of the switch motor and keeping the operating winding and stick winding of the overload relay in agreement. The PN-150BM is a biased relay with magnetic heavy duty contacts and is used for closing the switch motor circuit and opening it under abnormal conditions. These two relays in combination are also self-checking because of the bias feature on the PN-150BM relay.

Figure 2-5 through Figure 2-8 (view B) are typical switch control circuits using the PP-151 and PN-150BM relay combinations. Figure 2-5 through Figure 2-8 (view C) are typical switch control circuits using two PN-150BM relays in place of the PP-151/PN150BM combination.

The DP-25, PNP-69, and PN-150BM relays are capable of breaking stalled switch motor current in excess of 50 amps at 110 VDC.

For switch machine installations with shelf type relays, the DP-25 is used. It is available with two neutral magnetic blowout contacts for a double break switch motor circuit. Conversion of the DP-25 relay with one magnetic blowout contact (without low-voltage neutral contacts) to one having two magnetic blowout contacts can be accomplished by following Service Specification SM 2378N.

The typical circuits shown are intended to illustrate principles and should not be used as working drawings. Pole changing contacts and other circuits not shown for control of the WR relay should be in accordance with the circuits designed for the specific installation.

For converting between five- and three--wire control, refer to paragraph 2.11.4. If the layout calls for a left-hand point normally closed, interchange leads as called for in the note on Figure 2-5, Figure 2-6, Figure 2-7, and Figure 2-8. The circuit controller cams for the indication contacts should also be reversed as outlined in Section 2.11.2.

An internal wiring diagram is enclosed with each switch machine when shipped. Consult ASTS USA for specific field wiring applications.

If the latch (see Section 3.4) is arranged to be “self-restoring,” the control and indication circuits should be examined before installing the switch machines to make sure that the circuits will not prevent the machine from operating to restore the latch automatically following a latch-out.

All machines have two leads from the main terminal board to the circuit controller compartment to accommodate the application of a circuit controller heater in the field if the machine is not already so equipped (see Section 3.9).

2.8. Initial Lubrication

Apply a light coat of gear lubricant (Spec. M-7652-3; shipped with the machine) to the teeth of the spur gear only. Put the remainder of the lubricant into the worm gear compartment to a level no higher than the top of the worm gear. See lubrication chart in Figure 5-3 and Figure 5-4. All

other working parts of the machine have been sufficiently lubricated at the factory and do not require additional lubrication at this point.

NOTE

When applying lubricant, it is not necessary to remove the oil slushing compound with which parts are factory coated to provide protection against corrosion during shipment and storage.

The pins holding the lock rod control rod, point detector, control rod, and operating rod should also be lubricated at this time.

2.9. Lever Position and Interlock

In general, the position of the selector and hand-throw levers will be as shown in Figure 2-9, and the interlock will ordinarily permit the selector lever to be returned to its MOTOR position when the hand-throw lever is in either the Normal or Reverse position. However, certain deviations from these usual standards are feasible. The various arrangements are as follows:

- a. Both levers must always be on the field side of the machine, that is, on the left side for a LH machine and LH layout and on the right side for a RH machine and RH layout. To change between RH and LH, refer to Section 5.5.2.
- b. The hand-throw lever will always move the switch in the direction to close the near point when the lever is operated toward the motor end of the machine. This characteristic cannot be changed.
- c. For the standard arrangement, the selector lever is assembled to be toward the motor end of the machine when the lever is in its MOTOR position as shown in Figure 2-9. When desired, however, the lever can readily be assembled to be toward the circuit controller end of the machine for MOTOR position and the interlock arranged to suit, as described in Section 5.5. The cast MOTOR and HAND marker plates on the selector lever are interchangeable.
- d. The lever interlock can be arranged to either (1) allow the selector lever to be returned to MOTOR position when the hand-throw lever is in the Normal or the Reverse position, or (2) require the hand-throw lever to be in Normal position only before a selector lever can be returned to MOTOR position. Machines are shipped with option (1) assembly unless the order specifies that hand-throw lever must be Normal only.

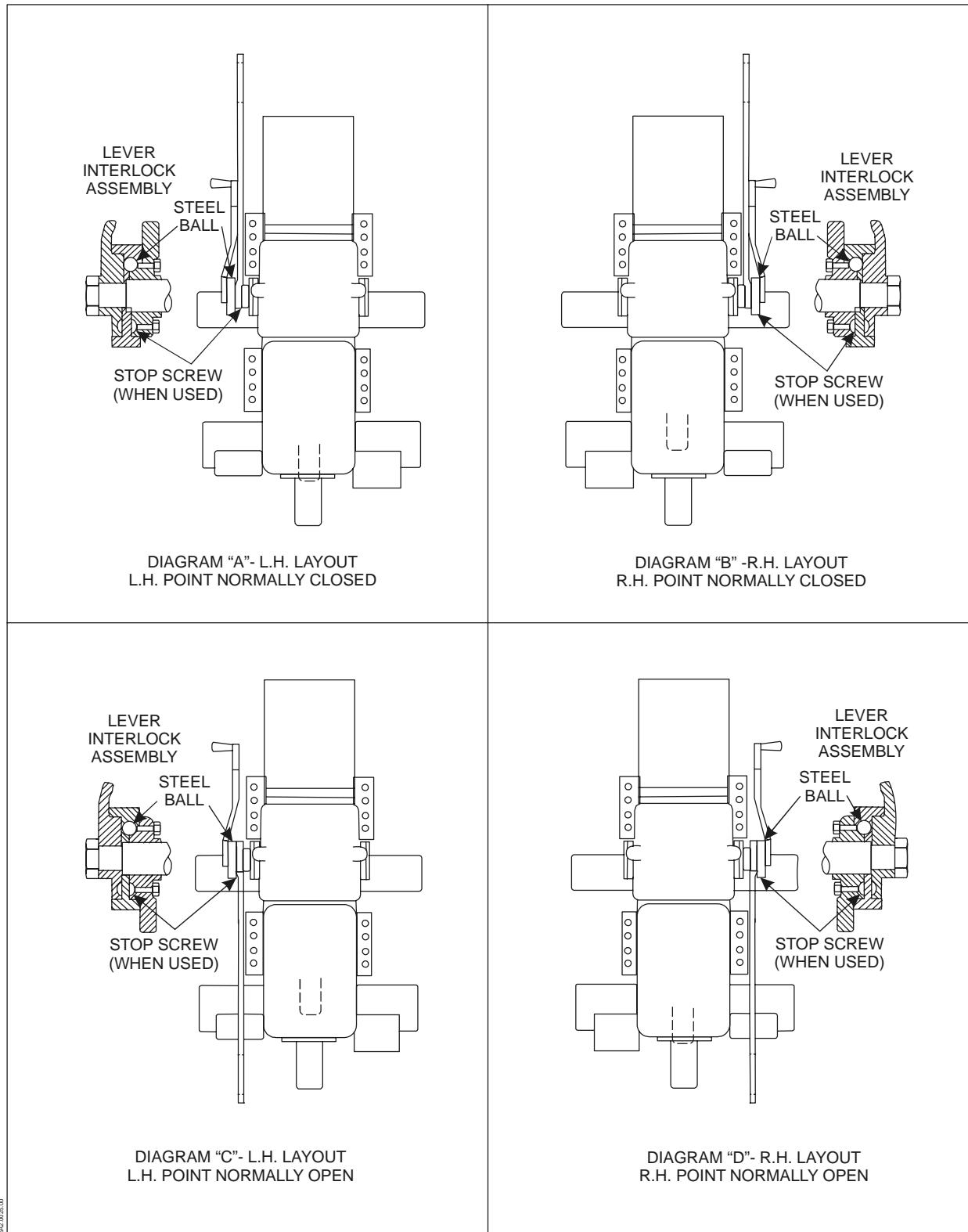


Figure 2-9. M-23 Switch Machine Standard Lever Interlock Assemblies

2.10. Prior To Placing Machine In Operation

- a. Check the lids for proper fit. Adjust if necessary.
- b. Check the motor cutout to be certain it is operating properly. Be sure that the crank cannot be inserted without the cutout contacts being latched out. Adjust if necessary per Section 5.7.2.
- c. Check wiring for proper connections.
- d. Check the clutch adjustment.

With an obstruction of at least 3/8" between the switch point and the stock rail, electrically operate the machine. When the switch point jams against the obstruction, the worm gear and worm shaft will be stopped but the motor should continue to run during the overload time delay period, slipping the friction clutch. Motor current during this period should be within 10% of the values specified in

Table 5-2, Section 5.5.5.3. If necessary, readjust the friction clutch spring to obtain the specified clutch slip current.

NOTE

If the friction clutch slips too easily, the motor current may not operate the overload relay and battery exhaustion may occur. If the friction clutch adjustment is too tight, unnecessary wear on the mechanical parts may occur due to absence of shock protection. In ordinary operation without obstruction of the switch points, the clutch might slip slightly at both ends of the power stroke.

2.11. Supplemental Information

This section provides additional specific information on the following:

- a. Changes that may be necessary in the assembly at the time of installation, if the switch machine (as ordered) does not suit conditions at the location.
- b. Inverting lock box to agree with lock rod notching.
- c. Shifting indication cams to have contacts at left indicate Normal.
- d. Converting between high-voltage and low-voltage.

2.11.1. Inverting the Lock Box

As explained in Section 3.1, lock box dogs must enter the narrow notches of the lock rod before reaching the wide notch. In some cases it may be necessary to invert the lock box to obtain this condition.

Installation and Adjustments

When inverting the lock box is necessary, remove the lock rods and proceed as follows (see Figure 3-5):

- a. Place the machine in the end-stroke position, which brings lock box G nearest the motor. Note which one of the indication cams N or P has its notch up, and that this notch is centered about roller D.
- b. Unscrew bolts T, which hold the circuit controller to the case. Swing the controller upward, pivoting it about the edge of the case adjacent to the wire conduit.
- c. Turn lock box G upside-down, taking care that it is replaced properly on the driving studs of the slide bar.
- d. Reinstall the circuit controller, checking that pinion gear F (Figure 3-6) meshes with the rack teeth on the lock box in such manner as to place the indication cam with its notch up and centered about roller D the same as it was before the circuit controller was removed.
- e. Fasten the circuit controller in place with bolts T.

2.11.2. Shifting the Indication Cams

WARNING

Electric shock or personal injury may occur if motor and indication power is not disconnected before shifting the indication cams.
--

Indication cams N and P (see Figure 3-5) are arranged so that either cam can have its notch up when the slide bar is at either end of its stroke. This permits standardized wiring by always having the indication contacts on the left side of the circuit controller indicate Normal, regardless of which end of the slide bar and lock box stroke is designated Normal.

Each cam is driven by a stud in the side of the gear and has two slots so that it can be engaged with its corresponding stud in either of two positions. The cams are held engaged with their respective studs by spring force and an 8-32 Allen Head Set Screw (adjacent to slots) that is tightened against the gear hub after adjustments have been made.

To shift the cams from one position to the other, loosen the 8-32 Allen Head Set Screw (adjacent to the slots), then carefully (to avoid distortion of contact springs) insert two screw drivers between the cam and the gear. Force the cam away from the gear against the force of its coil spring, and then rotate the cam to the alternate position until it snaps in place (see Figure 3-7). Tighten set screws in place.

Repeat this process for the other cam. (The two cams must be shifted individually).

2.11.3. Converting Between High- and Low-Voltage

Conversion between high-and low-voltage operation involves the gear ratio, motor, and wiring. The desired gear ratio may be obtained by changing the reduction gearing in accordance with the information given under “Gear Train” in Section 3.5.

The high- (or low-) voltage motor may be replaced by the low- (or high-) voltage motor by making the required wiring changes. Figure 2-5 and Figure 2-6 show low voltage wiring and Figure 2-7 and Figure 2-8 show high voltage wiring.

2.11.4. Converting Between Five- and Three-Wire Control

Conversion of switch machine between five- and three-wire control may be performed in the field by rearranging jumper lead connections on the terminal board. Additional leads necessary for the conversion are supplied with all switch machines (in a bag attached to the terminal board). Before any conversion is performed, identify the type of control currently used. High voltage three-wire control may be identified by the presence of a jumper from terminals A to B, or A to C. Low voltage three-wire control may be identified by a jumper from terminal 34 to C or 34 to B. Five-wire control may be identified by the absence of these jumper connections. See Figure 2-5 through Figure 2-8 (view A) for the location of these jumpers. Perform one of the following sequences to accomplish the conversion:

- Five- to Three-Wire Control, 110 VDC
 1. Remove lead D to A.
 2. Add lead D to 5.
 3. Add lead 10 to 35.
 4. For left hand operation, add lead A to C.
 5. For right hand operation, add lead A to B.
- Three- to Five-Wire Control, 110 VDC
 1. For left hand operation, remove lead A to C.
 2. For right hand operation, remove lead A to B.
 3. Remove lead 10 to 35.
 4. Remove lead D to 5.
 5. Add lead D to A.
- Five- to Three-Wire Control, 20 VDC
 1. For left hand operation, add lead C to 34.

Installation and Adjustments

2. For right hand operation, add lead B to 34.
- Three- to Five-Wire Control, 20 VDC
 1. For left hand operation, remove lead C to 34.
 2. For right hand operation, remove lead B to 34.

NOTE

Control wiring logic must be in correspondence with Figure 2-5 through Figure 2-8.
--

3. OPERATION

3.1. Switch-Operating and Locking Mechanism

The main crank drives both the switch-operating bar and the slide bar. The latter carries the lock box with its locking dogs which enter notches in the lock rods when the switch points are in proper position, and also carries rack teeth which operate the circuit controller. Assuming the machine to be at one end of its stroke, operation to the opposite end of the stroke involves rotation of the main crank by the motor or by the hand-throw lever. As the main crank turns, it first shifts the slide bar so as to withdraw the locking dog from the lock rod notch before the switch points start to move, then the main crank holds the slide bar in the mid-position (both locking dogs clear of the lock rods) while driving the switch-operating bar full stroke to its opposite position, and finally the main crank holds the switch-operating bar while driving the slide bar to its full-stroke position engaging the top locking dog in the corresponding lock rod notch.

The manner in which the crank imparts these motions can be understood by referring to Figure 3-1, Figure 3-2, and Figure 3-3. The main crank is designated X, the switch-operating bar Y and the slide bar Z.

Assuming that Figure 3-2 and Figure 3-3 show the Normal position, a reverse movement is started by a clockwise rotation of main crank X.

Lug x^1 on top of main crank X acting against roller z^1 on slide bar Z effects the unlocking of the lock rod by causing slide bar Z to move to the left one-half of its stroke. Meanwhile, roller x on the underside of main crank X is moved through an arc of 40 degrees in the radial portion of groove y in switch-operating bar Y, thus freeing the bar for the reverse stroke. During the next 140 degrees of rotation of main crank X, roller x engages the straight (reverse) operating face of groove y and moves the switch-operating bar Y to the reverse position.

Figure 3-2 and Figure 3-3 show the relative mid-stroke positions of switch-operating bar Y and slide bar Z; crank X is still rotating clockwise but is not transmitting motion to slide bar Z as lug x^1 has become disengaged from roller z^1 . Surfaces v and v^1 of slide bar Z are radial to the center of the shaft and prevent the slide bar from moving.

The full reverse position is shown by Figure 3-2 and Figure 3-3. Roller x on crank X acting in groove y has moved switch-operating bar Y to the reverse position and secured it against back thrust; lug x^2 has come into contact with roller z during the last 40 degrees of rotation of crank X, thus driving slide bar Z to its full reverse position.

Connection to the switch points may be made at either end of switch-operating bar Y to suit the particular switch layout. The position of the switch points is checked and secured by the action of the lock box.

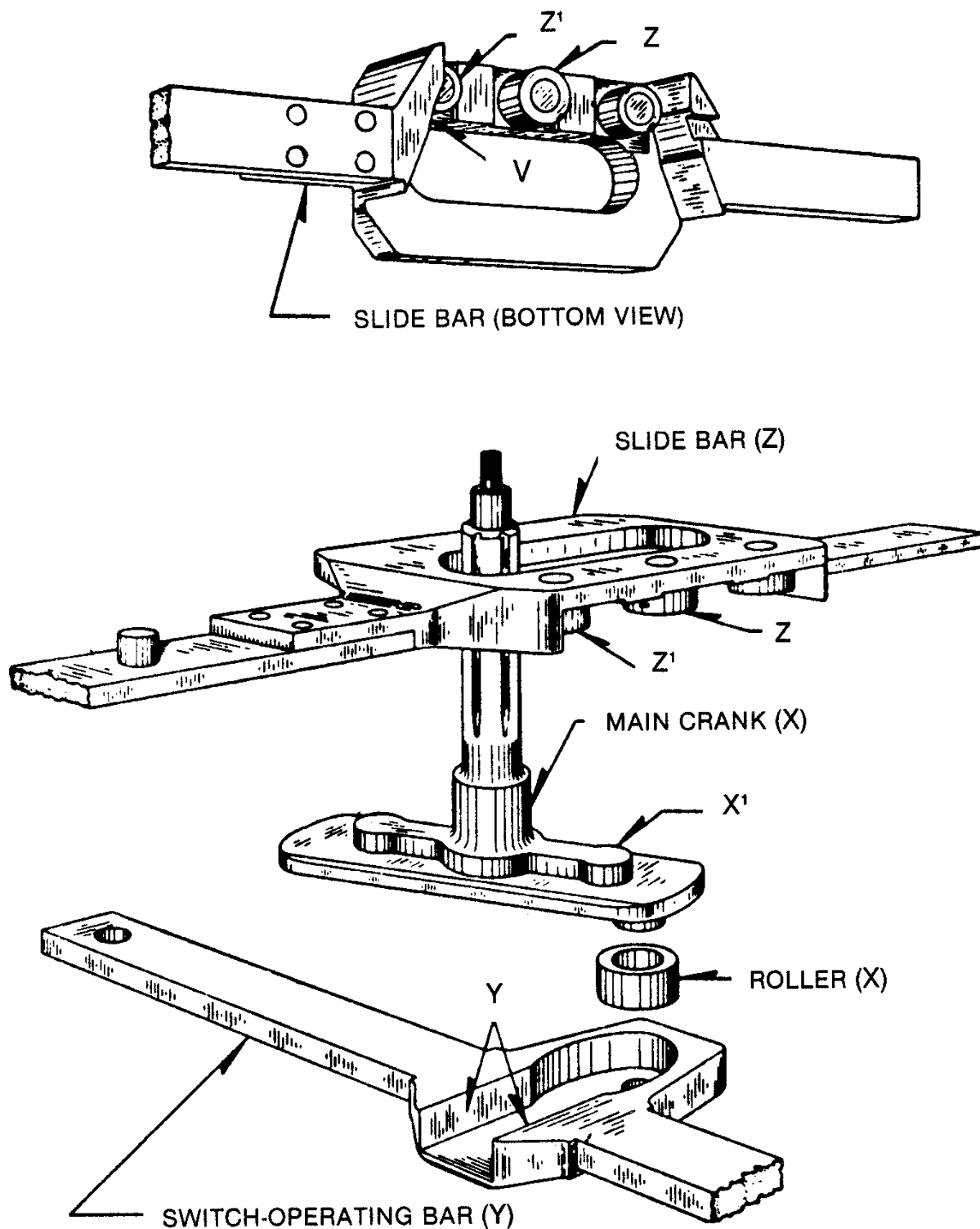


Figure 3-1. Schematic Diagram of Switch-Operating Mechanism

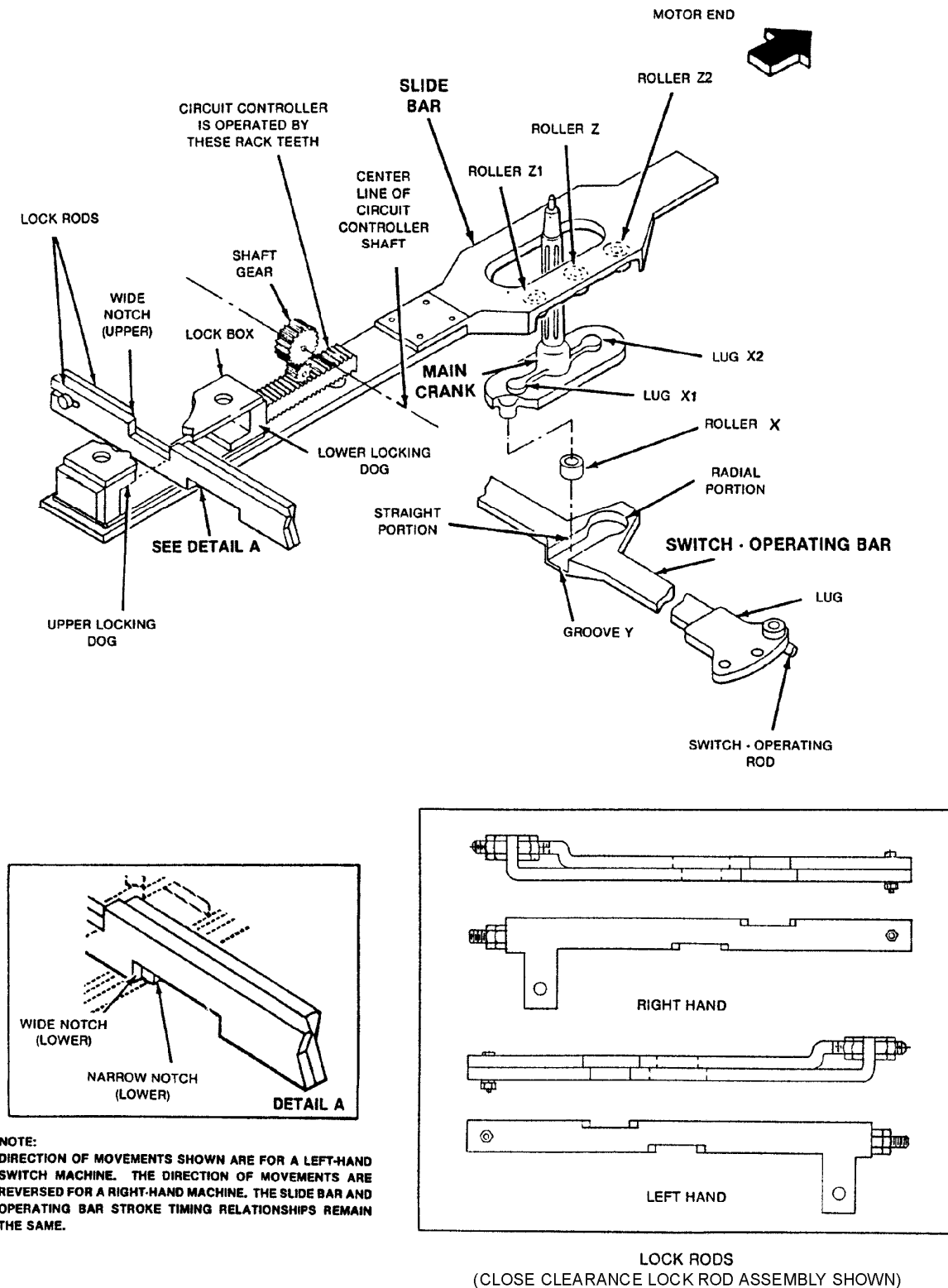


Figure 3-2. Diagram of Driving Parts (Sheet 1 of 2)

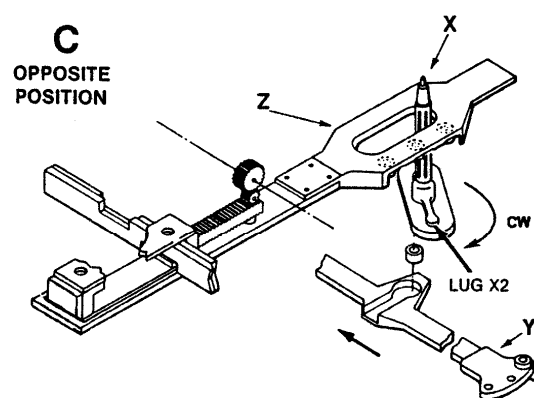
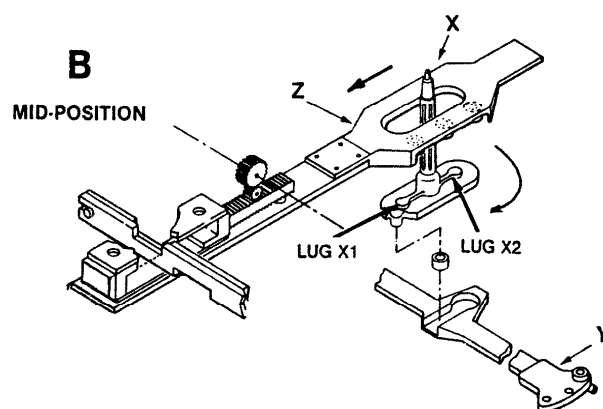
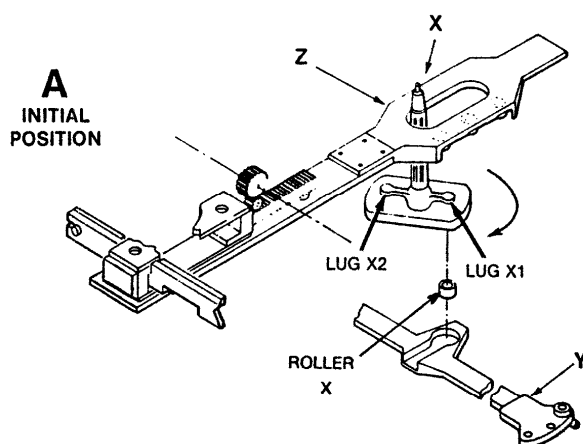
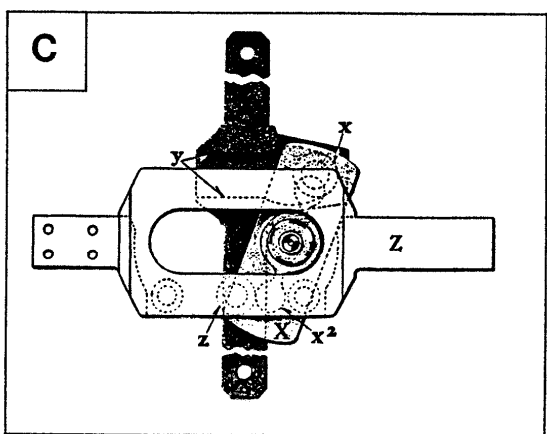
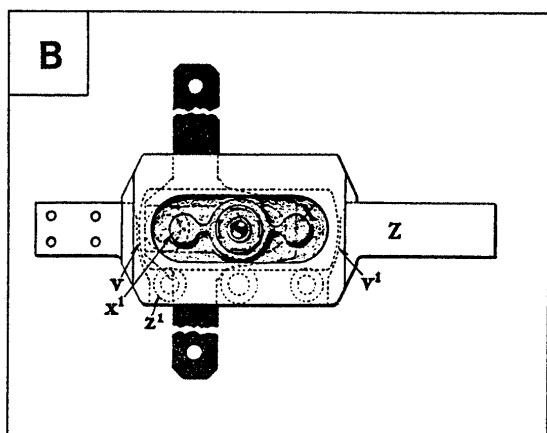
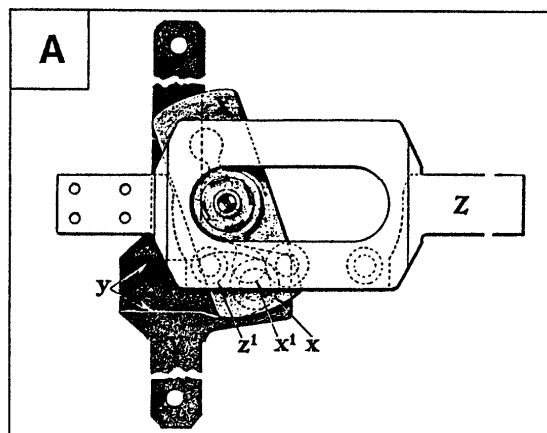


Figure 3-3. Diagram of Driving Parts (Sheet 2 of 2)

The lock box rests on and is operated from an extension of the slide bar as shown in Figure 3-2 and Figure 3-3. During the first 40 degrees of rotation of the main crank, the corresponding motion of the slide bar withdraws the lower locking dog of the lock box from the lower notch of the lock rod, thus unlocking the switch points. The following 140 degrees of rotation of the crank operates the switch, and the lock rod stops with its upper notch aligned to receive the upper locking dog of the lock box. The final 40 degrees of rotation of the crank completes the stroke of the slide bar, driving the upper locking dog into the lock rod notch to lock the switch points in the reverse position.

3.2. Switch Point Locking

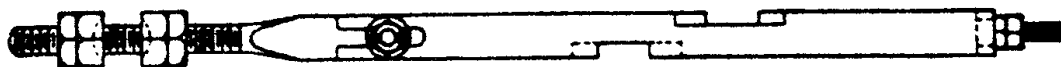
The lock rods in Figure 3-4 are comprised of two rectangular rods side-by-side. Each has a narrow notch only slightly wider than the locking dogs, this narrow notch in one rod being on top and in the other rod on the bottom. To allow for variations in switch throw, the two rods are adjustable longitudinally with respect to each other, and each has a wide notch located alongside the narrow notch of the other. As the notch is on top of the lock rods for one position of the switch and on the bottom for the other position, and as the lock box likewise has one dog on top and the other on the bottom, it follows that the slide bar with its lock box can complete its stroke only if the lock rods are shifted by the switch points to the position corresponding to proper point closure. When the stroke is completed, the switch, of course, is secured by the locking.

The stroke of the slide bar and its lock box is such that the locking dogs provide adequate interlock with only the lock rod that the dog enters first. Therefore, the lock box and the lock rods must be so assembled that the dogs will enter the narrow notches first. Procedure for inverting the lock box when necessary is given in paragraph 2.11.1.

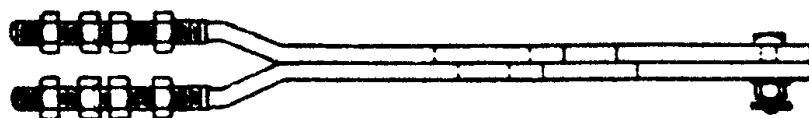
3.3. Circuit Controller

The circuit controller has indication contacts that are operated jointly by the lock box and the point detector mechanism. The contacts are operated in such a manner that the machine, as checked by the lock box, must have completed its throwing and locking stroke in the proper direction, and the corresponding switch point must be closed properly, as checked by the point detector, before the corresponding indication contacts can close. It also has segmental type motor control contacts for opening the motor circuit when the machine is in its full normal or full reverse position.

As shown in Figure 3-5, the circuit controller has a total of 8 sets of contacts operated by cams and segments on shaft R which is rotated by the slide bar motion transmitted through the lock box rack teeth, the idler pinion, and the shaft gear. The two sets of contacts at the left side (viewed from lock rod end of the machine, Figure 3-5) and the two at the right side comprise the motor control contacts, while the four intervening sets comprise the indication contacts. The motor control contacts are operated solely by the shaft-carried segments, but the indication contacts are also subject to point detector operation.



(A) TYPE GENERALLY USED WITH BALL AND SOCKET CONNECTION



(B) TYPE USED WITH RIGID CONNECTION

Figure 3-4. Adjustable Lock Rods for R.H. and L.H. Operation

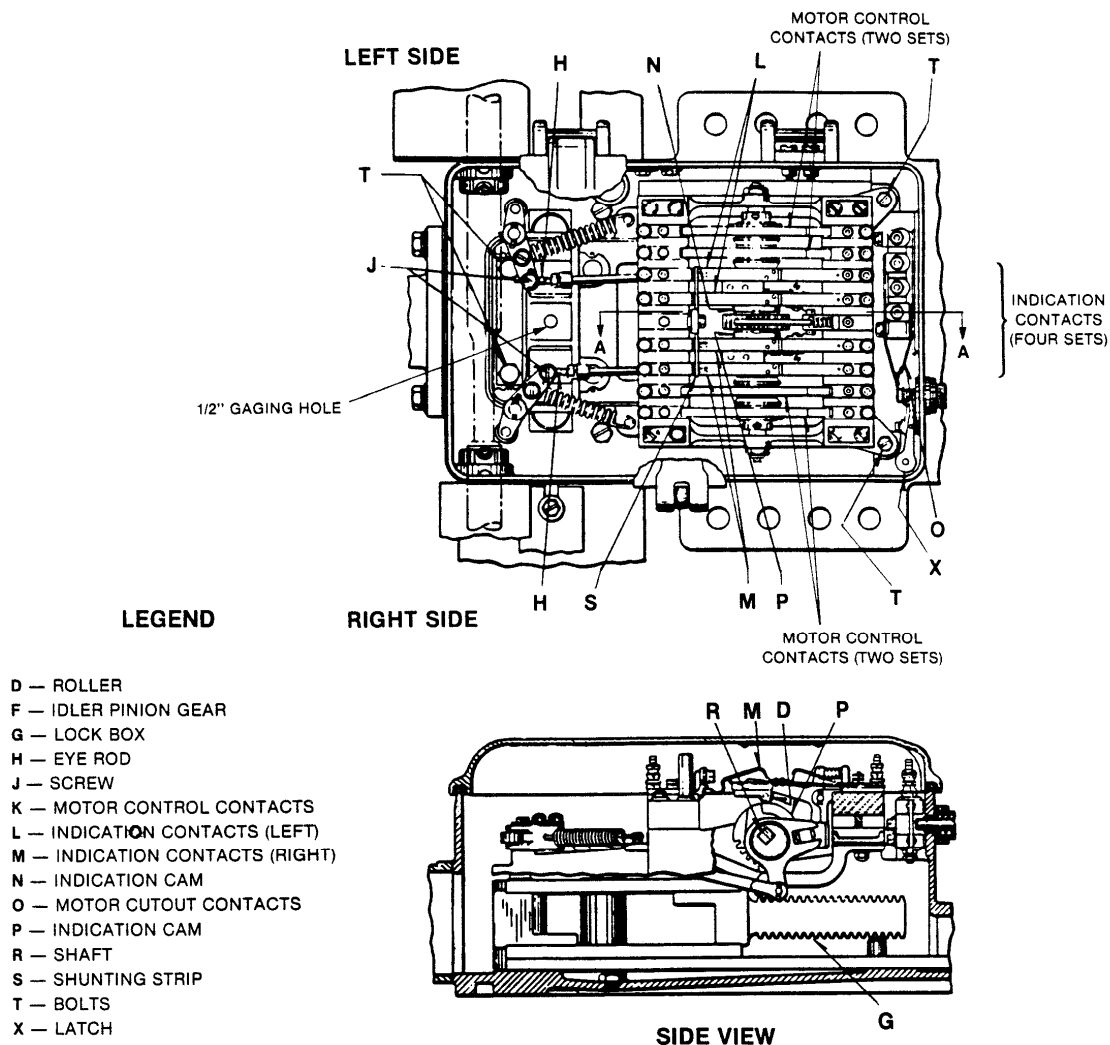


Figure 3-5. Indication Circuit Controller

The shaft assembly, Figure 3-7, consists of a square shaft on which the two end insulating washers, the four motor control segment insulating bushings, the two eccentric bushings, and the gear each have square holes to force them to rotate with the shaft. To ensure proper relative assembly of the gear and eccentric bushings, the shaft is made with unlike ends so that it can go into the controller only one way. The shaft has one corner flattened for a distance of 2" at one end and 3" at the other end, and the gear and the eccentric bushings have dowel pins that can be assembled only in these flats. With the exception of the indication cams and their coil springs, the two arms of the yoke, and the operating levers, all the parts are pulled up solidly end-to-end by the nuts on the ends of the shaft. The indication cams and their respective springs ride on the gear hub and are held against the gear face by action of the springs and locked in place with set screws. The cams may have either of two operating positions as determined by slots in the cam hub engaging the stud in the gear face. The yoke is free to rotate around the concentric hub

portions of the eccentric bushings, and the operating levers are free to rotate around the eccentric portions or be held stationary while the shaft and eccentric bushings rotate.

3.3.1. Indication Contacts

The four sets of indication contacts operate as two pairs, one pair indicating the normal position and the other indicating the reverse position. Each pair is operated by a single cam and both are subject to point detector operation. Wiring and wire nomenclature are standardized so that the left pair of contacts (L, Figure 3-5; Sect. N-N, Figure 3-7) are used to indicate “normal” on all installations. This means that in some applications the left pair of contacts must indicate that end of the stroke that has the slide bar toward the lock rod end of machine, and in other applications must indicate that end of the stroke that has the slide bar toward the motor end of the machine. The right pair of contacts (M, Figure 3-5) similarly must indicate sometimes one end and sometimes the other end of the slide bar stroke, so as to indicate “reverse.”

Referring to Figure 3-6, when cam N has its notch up, the associated “normal” pair of contacts L closes as shown (except when prevented by point detection, as explained later). For a right-hand layout with right-hand point normally closed cam N has its notch up when the slide bar is at that end of its stroke where it is nearest the motor end of the machine. At the same time, cam P is holding its associated pair of contacts up (Sect. P-P and Sect. N-N of Figure 3-7). When the machine is operated towards the opposite end of its stroke, the notch in cam N rotates counterclockwise out from under the follower, forcing the contacts up. While the switch is in transit, both the normal and the reverse indication contacts are up, engaging the shunting strip S (Figures 3-4 and 3-6) to provide a shunt for the indication relay. When the machines leave the factory, this strip is assembled to connect one normal and one reverse contact, but may be reassembled to shunt all four contacts when indication circuits require such arrangement. When the machine reaches the end of its stroke, the notch in cam P comes on top and thus permits the “reverse” pair of contacts to close (except when prevented by point detection).

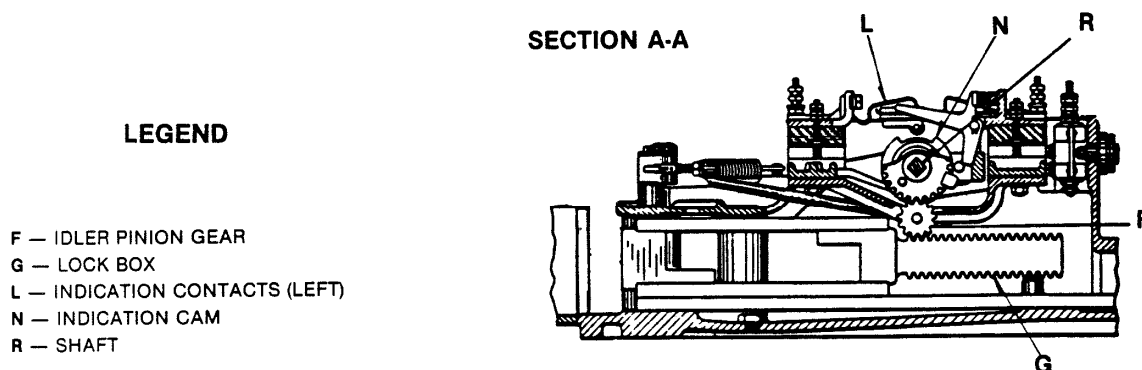


Figure 3-6. Sectional View of Indication Circuit Controller



Instructions for shifting the cams to reverse the ends of the stroke at which they have their notches up, and for adjustment of the contacts, are given in sections 2.11.2 and 5.5.6.2, respectively.

3.3.2. Motor Control Contacts

Of the four sets of motor control contacts (Figure 3-5), the two on the right side (viewed from lock rod end of machine) are open and the two on the left side are closed when the machine is in the position shown. When the machine reaches full opposite position, the closed contacts have been opened to break the motor circuit and the open contacts are closed to provide a circuit for operating the machine back to its original position.

Each set of motor control contacts provides two parallel circuit paths, one through direct contact of opposing spring fingers F1 and F2 (Figure 3-7) and the other through finger F1, the conducting segment, and finger F3. The circuit through the segment opens last, as the notch passes under the “V” end of the finger F1, finger F2 being stopped first before the “V” end clears the segment altogether. This arrangement protects the direct finger contact from having to open the motor circuit under normal conditions, yet ensures a circuit in case the segment should become coated with frost.

Referring to Figure 3-7, it will be noted that each motor control segment is nested on the tapered hub of its insulating bushings. The cone engagement has teeth in both elements that prevent the segment from rotating relative to the shaft when the shaft end nuts are pulled up, but that permit the segment to be shifted angularly around the shaft in 4-degree steps when the shaft end nuts are backed off. These segments are set in the factory to provide approximately 1/4” opening between the segment ring and the “V” end of the contact finger F1 (Sect. Y-Y and Z-Z) and approximately 1/8” margin against opening under finger F3 (Sect. W-W and X-X) when the machine is in its full stroke position (operated as far as it will go by rotating the friction clutch by hand while in MOTOR position).

The motor control contacts are set at the factory to ensure that the switch machine is locked in accordance with AREMA specifications. Ordinarily, readjustment will not be required as long as the assembly remains undisturbed. If an adjustment is required, it would be best to adjust the machine in the maintenance shop. Refer to Section 5.5.6.1 for these procedures.

3.4. Point Detector

The indication contacts are positively opened by the lock box action, and merely permitted to close when the cam notches are aligned – unless closure is prevented by point detector action. Point detector checks switch point closure separately from the lock rod connection, and is used not only to check the switch point when it is first closed but also to detect damage to a switch point caused by dragging equipment or by traffic running through the switch improperly while the machine is in the locked-up position. The point detector apparatus in this circuit controller is “selective” (like the locking) in that the point detector bar must shift to correspond with the switch operating stroke when the machine is reversed. It also has a latchout feature that will hold

the indication contacts open (until reset) when the point detector bar is displaced while the machine is in the locked-up position.

The latch is arranged to take advantage of the considerable displacement of the point detector bar which occurs at the time the switch points are being deflected by improperly trailing traffic or by dragging equipment, so that the contacts are prevented from indicating even though the points may subsequently spring back and leave the point detector bar near its original position. Thus, protection is provided in case the switch points have been damaged in such a way as to be unsafe for facing point traffic yet so distorted as to leave very little net shift of the point detector bar. The latch is equipped with a “self-restoring” feature (which may be readily removed if not wanted) to take care of situations where the latch may become unnecessarily latched up due to unusual traffic shocks that do not affect the fit of the switch point against the rail. The latch will reset automatically when the machine is next operated to withdraw the locking dog from the lock rod notch. If the latch were latched-up as the result of damage to the switch point, it would be impossible for the machine to complete its stroke in either direction due to lock rod fouling. The latch can also be reset manually.

Major components of the point detector mechanism are shown in Figure 3-5 and the relative positions of the eccentric bushings, operating rods, and point detector rollers for the normal^{*} position of the switch machine are shown in Figure 3-8. Mid-stroke positions of the various parts are shown in Figure 3-9. Reverse positions of the various parts are shown in Figure 3-10 while Figure 3-11 shows the various parts latched-up in the reverse position.

The right and left-hand operating crank springs hold the yoke, which is pivoted on the controller shaft, against the yoke stop on the latch bracket for all controller positions, except when the point detector bar has been displaced due to improperly positioned switch points. That is, for normal operation of the machine with the switch points in proper adjustment, the yoke assembly remains in a fixed position as shown in Figure 3-8, Figure 3-9, and Figure 3-10.

^{*} Parts are illustrated for machine in which cams are assembled for Normal end of stroke to be that which places switch points to the right.

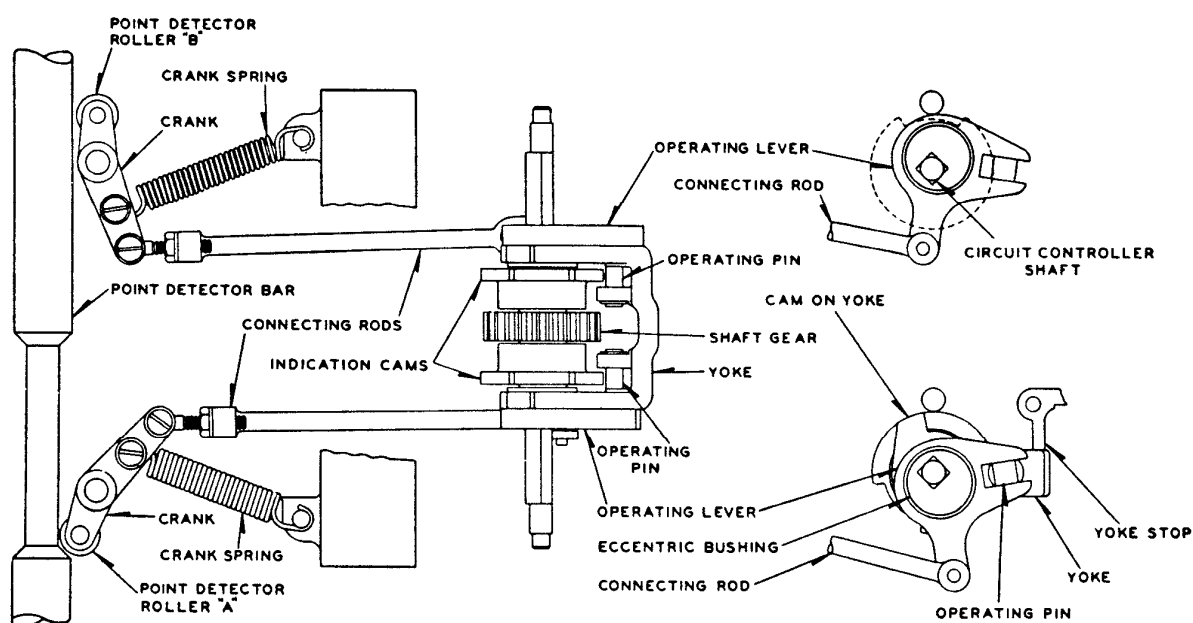


Figure 3-8. Schematic Diagram of Point Detector – Parts in Normal Position

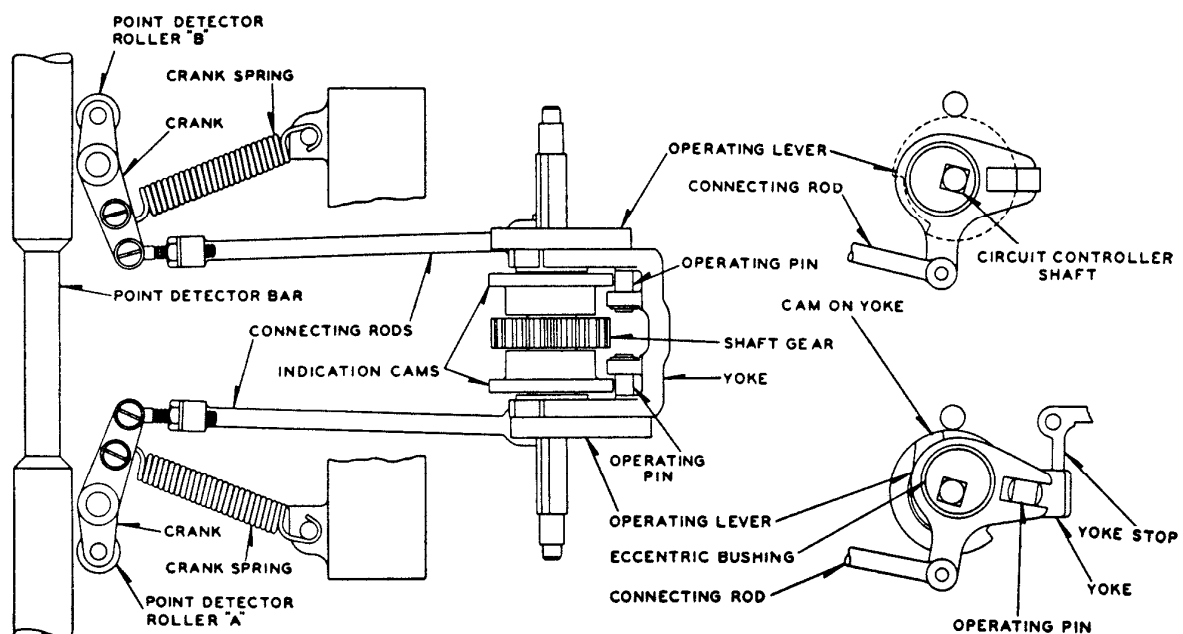


Figure 3-9. Schematic Diagram of Point Detector – Parts in Mid-Stroke Position

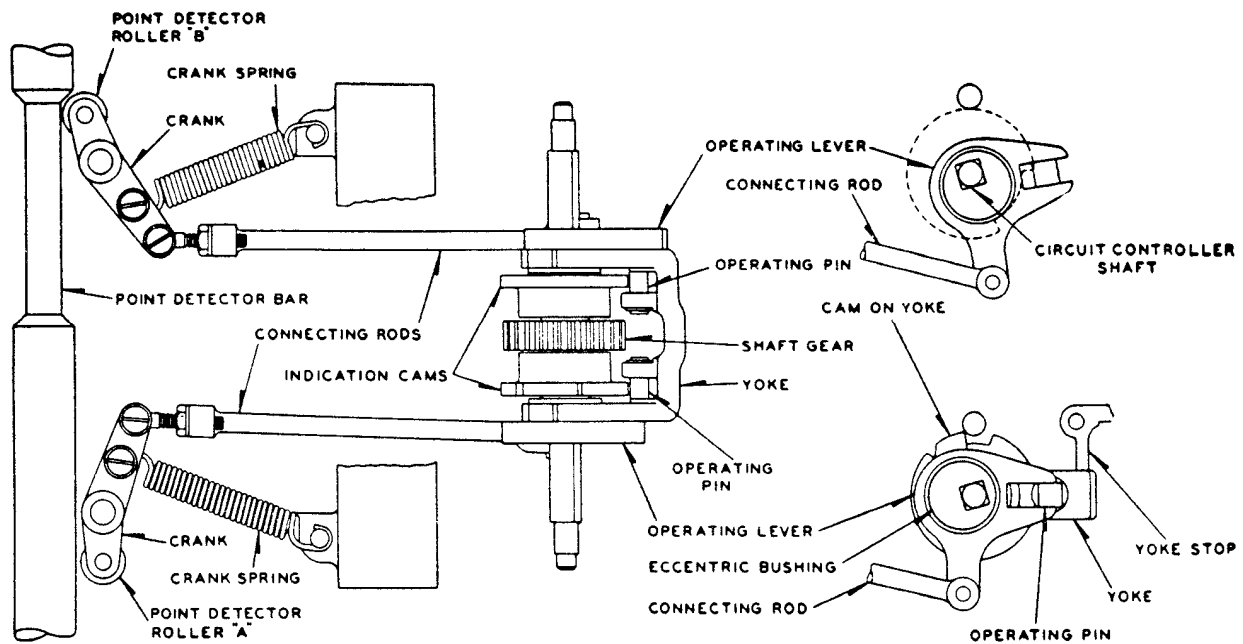


Figure 3-10. Schematic Diagram of Point Detector – Parts in Reverse Position

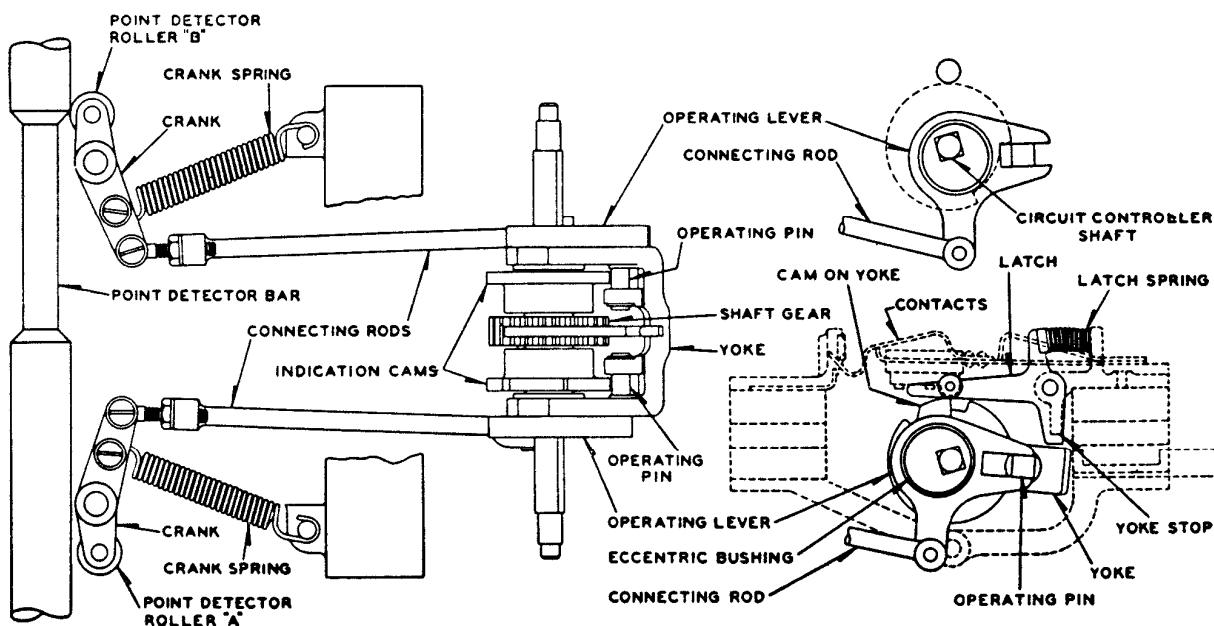


Figure 3-11. Schematic Diagram of Point Detector – Parts in Reverse Position and Latched-Up

With the switch machine in the normal position, as shown in Figure 3-8, point detector rollers A and B stand clear of the point detector bar, thus preventing wear of point detector parts under

Operation

traffic conditions. Roller A, however, is in position to deflect the yoke downward should the point detector bar be displaced. When the machine is operated out of the normal position, the controller shaft rotates in a counterclockwise direction (viewed from right-hand side) and the operating levers are shifted by the eccentric bushings so as to move point detector roller A away from the point detector bar and permit movement of the point detector bar from the normal to reverse position without contacting either roller. Mid-stroke positions are shown in Figure 3-9.

Reverse positions of the parts are shown in Figure 3-10. Both rollers are again clear of the bar, but roller B is in position to deflect the yoke downward should the point detector bar become displaced.

The latched-out position of the circuit controller is shown in Figure 3-11. In this position, the point detector bar has been shifted from its reverse position due to deflection of the switch points caused by improper trailing. The large diameter of the point detector bar has been brought into contact with point detector roller B, resulting in the connecting rod shifting the operating levers and, thereby, rotating the yoke downward about the controller shaft until the latch, as biased by the latch spring, snaps over the top of the yoke midsection. ^{**} As the yoke is rotated downward, the upright cam portion of the yoke engages the roller on the under side of both indication contact assemblies and, thereby, lifts the reverse contact assembly to open the reverse indication contacts and to close the indication contacts against the short-circuiting strip. The latch can be restored manually or by operating the machine to the opposite position so that the cam on the controller shaft gear in mid-stroke will lift the latch to permit the yoke to be restored to its horizontal position resting against the yoke stop.

3.5. Gear Train

The reduction gear train between the motor and the worm gear consists of a pinion on the end of the motor shaft, one or two reduction gears, clutch gear, friction clutch, worm shaft and worm gear (see Figure 3-12 and Figure 3-13). Note that each reduction gear actually consists of two gears, a large gear and a small gear, made as a unit. The gear ratio is changed by changing out the reduction gears, using the combination listed in Table 3-1.

^{**} If the latch doesn't clear the top of the yoke and operate, add sufficient shims under the yoke stop (see Figure 3-11) until the latch operates.

Table 3-1. Gear Ratio – Reduction Gear Relationship

Switch Machine M-3, M-23A, or M-23B		110 VDC	110 VDC	20 VDC	20 VDC
Nominal Speed*		4.5 sec.	8 sec.	15 sec.	26 sec.
Gear Ratio		189:1	360:1	360:1	528:1
Number of Teeth Clutch Gear		43	43	43	43
1 st Reduction (Figure 3-12)	Gear	--	32	32	32
	Pinion	--	16	16	12
2 nd Reduction (Figure 3-12)	Gear	--	41	41	45
	Pinion	--	22	22	22
Motor Pinion		12	12	12	12

* See Operating Characteristics, Paragraph 1.4.2.

The pinion end of the motor is supported in an opening in the clear box which locates the pinion properly relative to the other gear centers. The motor can be removed by taking out the two bolts in the motor bracket at the commutator end. (For detail information on the motor, see paragraph 3.8.)

The reduction gears are assembled on shafts supported in Oilite bearings. The shafts are held in place endwise by the shaft end plate which is slotted to fit over a neck in each shaft. To remove these shafts to change out the reduction gears, it is necessary to first shift the motor out of the way (see previous paragraph).

The clutch gear, which is the final spur gear, has an Oilite bushing to support it on the worm shaft. This gear is connected to the worm shaft through the friction clutch as will be described.

The worm shaft meshes with the worm gear on the main crankshaft and is supported at the end adjacent to the controller by a double-row ball bearing that takes both radial load and end thrust. It also is supported by a single-row ball bearing in the wall between the worm gear compartment and the spur gear compartment. Both ball bearings are lubricated by the worm gear lubricant. A cap on the outside seals the outer side of the double-row ball bearing, and an oil seal pressed into the opening is provided on the spur gear side of the single-row ball bearing.

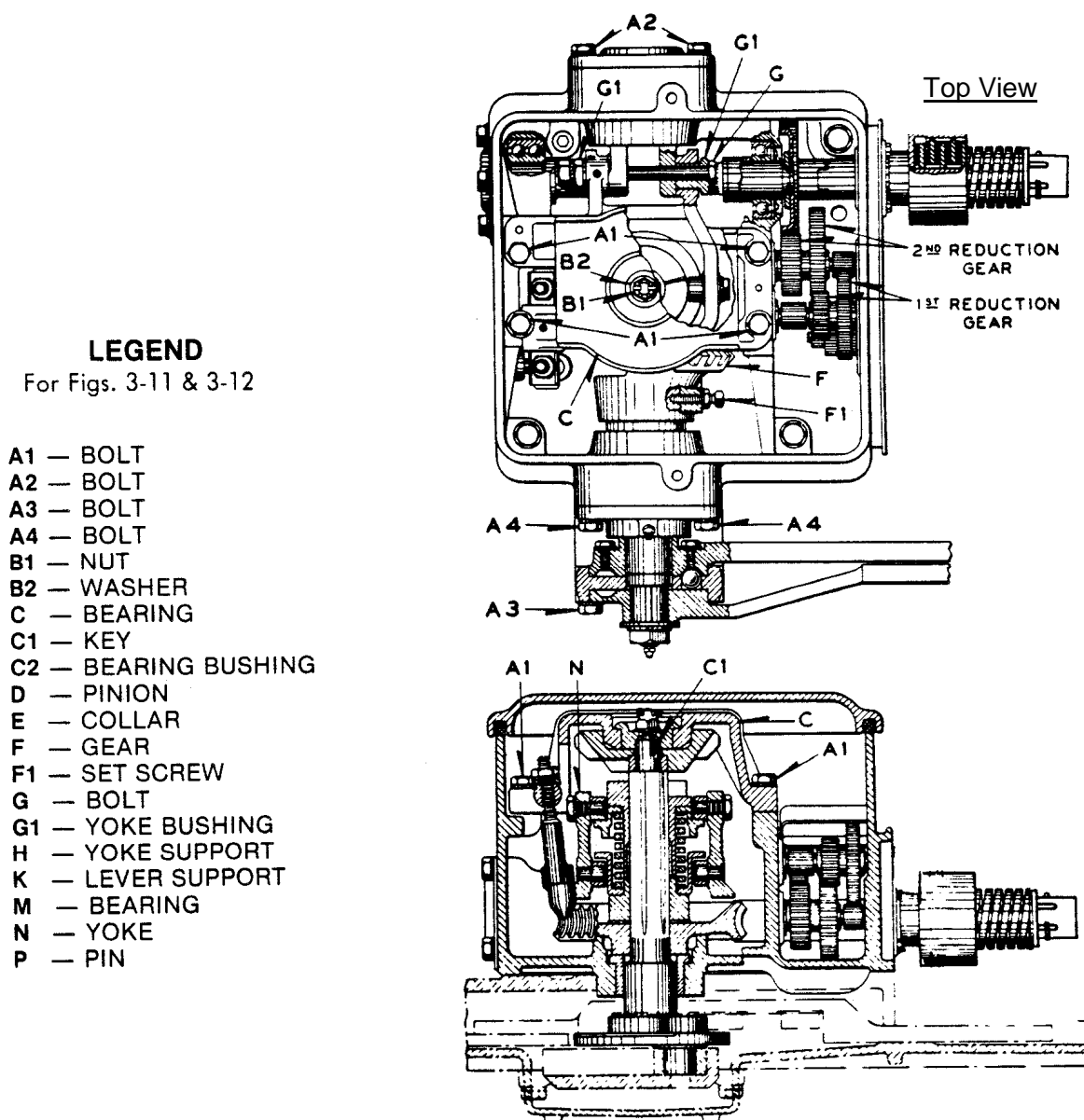


Figure 3-12. Sectional View of M-23A Gearbox

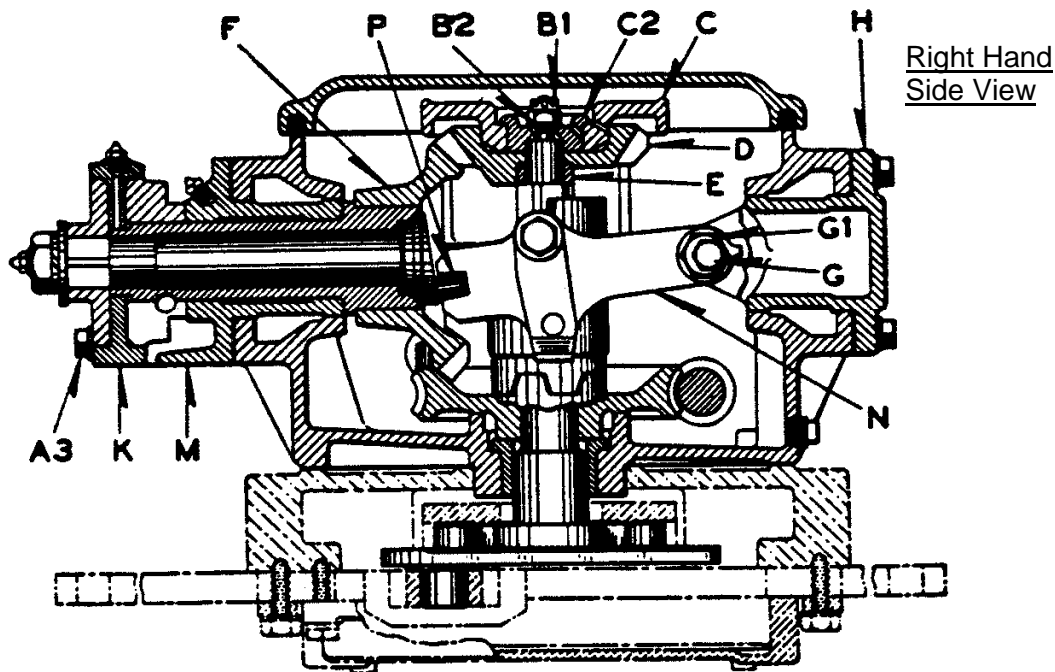


Figure 3-13. Sectional View of M-23A Gearbox, Looking from Motor End

The friction clutch housing has a tubular neck supported in an Oilite bushing pressed into the gearbox bore. The inside diameter provides slight clearance for the worm shaft. The housing has a felt washer and an oil seal to prevent seepage of oil into the friction clutch. The worm shaft is grooved and the housing has ribs to drive alternate friction discs that are compressed by the action of the heavy coil spring. This spring force is contained between the adjusting nut and Oilite thrust plate supported on the tapered shoulder on the worm shaft.

Note that the clutch gear hub has a three-finger engagement with the clutch housing tubular neck, so that the clutch housing is driven by the motor. Drive between the clutch housing and the worm shaft is through the friction discs.

3.6. Operation By Hand Crank – (M-3 Only)

Provision is made in the M-3 switch machine for hand operation by inserting a removable hand crank through the hand hole in the gearbox cover. Motor cutout contacts “O” (Figure 3-5) are operated by means of a linkage to open the motor circuit (and in some cases to open a control circuit) when the hasp for the hand hole cover is released, and the crank inserted. Latch X, which can be removed if not desired, serves to hold the motor cutout contacts latched out until reset manually – a useful feature when someone other than the signal maintainer is authorized to use the hand crank.

WARNING

In certain cases, particularly on transit properties, clearance is such that the hand crank may contact the vehicle collector shoe and present a personal and equipment hazard. Do not permit traffic through the switch area unless the hand crank has been removed.

3.7. Dual-Control Mechanism (M-23A and M-23B Only)

Switch operation, switch locking, and circuit controller operation are all performed by the vertical main crank in the gear compartment shown in Figure 1-2. This crank is always in engagement with either (a) the motor, through the reduction gear train and its friction clutch, or (b) the hand-throw lever, through the hand-throw pinion. The selector clutch slides along splines on the shaft of the main crank and is shifted up or down by the selector lever. To permit the selector lever stroke to be completed even though the top tooth of the selector clutch may not be in alignment with the tooth space in the hand-throw pinion hub when shifting from motor position (shown) to hand-throw position, connection between the selector lever and the selector clutch is made through a coil spring mounted on the selector clutch.

NOTE

In Figure 1-2, the top tooth is shown in alignment with the tooth space in the hub of the hand-throw pinion because the switch and the hand-throw lever are both in the Normal position. There may be times when the switch is blocked mid-stroke by an obstruction so that the main crank will not be in Normal position, and of course, if the last motor operation left the switch in the reverse position, the teeth likewise are not aligned.

The selector clutch will snap into engagement with the hand-throw pinion when the hand-throw lever is operated to a position corresponding with the switch position. This spring connection acts similarly when returning the selector lever to the motor position; however, in this case it is the motor that must be operated to align the worm gear hub teeth to receive the selector clutch teeth. Observe that the main crank remains engaged with its original connected driving elements until it is engaged with the other elements, as covered by Note A, Figure 1-2.

NOTE

In as much as the switch-operating mechanism may remain in engagement with the motor rather than with the hand-throw lever when the selector is operated to HAND position, it is necessary to actually operate the switch by the hand-throw lever to assure that the machine is in the hand operation position.

3.7.1. Operation By Selector Lever

The selector clutch assembly is shifted up or down by 180 degrees of rotation of the selector lever, the inner crank finger of which swings the selector clutch yoke up or down. This yoke has rollers on each side engaging the upper and lower spring cups of the selector clutch assembly.

The selector clutch assembly, as shown in Figure 3-14, has a spool-shaped core made in two parts which are screwed together and are held from becoming unscrewed in service by the splines in both portions. The upper part, or “clutch for hand operation,” has a single tooth on top for engaging the hand-throw pinion, which requires strict agreement of the hand-throw lever position with the position of the switch when engaged. The lower part has five teeth for engagement with the worm gear. The upper and lower parts are separable only when the assembly is removed from the splined shaft, this arrangement being used to permit assembly of the spring and two spring cups. The spring cups are ordinarily held tightly against the upper and lower flanges of the core by the compression force of the spring.

When the selector lever is operated 180 degrees from the position shown, one end of the selector clutch yoke will lift such that its lower rollers push upward against the underside of the flange on the lower spring cup. If the switch is in the position corresponding to the position of the hand-throw lever such that the tooth of the hand-throw pinion is aligned to receive the tooth of the “clutch for hand operation,” and assuming no restraining friction between the teeth at the bottom, the selector clutch assembly will shift upward without deflecting the spring. At times, however, there may be a torque load on the lower teeth when the selector lever is operated (for example, if the switch is stalled on an obstruction) and this may cause sufficient friction to hold the clutch down while the yoke is lifted. As a result, the spring will be compressed as the lower spring cup is lifted by the lower rollers on the yoke, until the top of the lower spring cup engages the bottom of the upper spring cup. Further operation of the selector lever provides a positive drive to pull the lower teeth apart far enough that the chamfered corners of the teeth engage, instead of the nearly vertical working faces. At this point the single tooth at the top of the clutch assembly is raised enough to begin engaging the hand-throw pinion, and will be forced into full engagement with it by the spring force and any upward thrust due to the torque load on the lower teeth (provided that the two upper teeth are aligned to permit this). If these upper teeth are not aligned, the spring will hold the “clutch for hand operation” against the hand-throw pinion tooth until the hand-throw lever is operated to obtain alignment.

The spring functions in a similar manner if the worm gear teeth are not aligned when the selector lever is returned to the motor position.

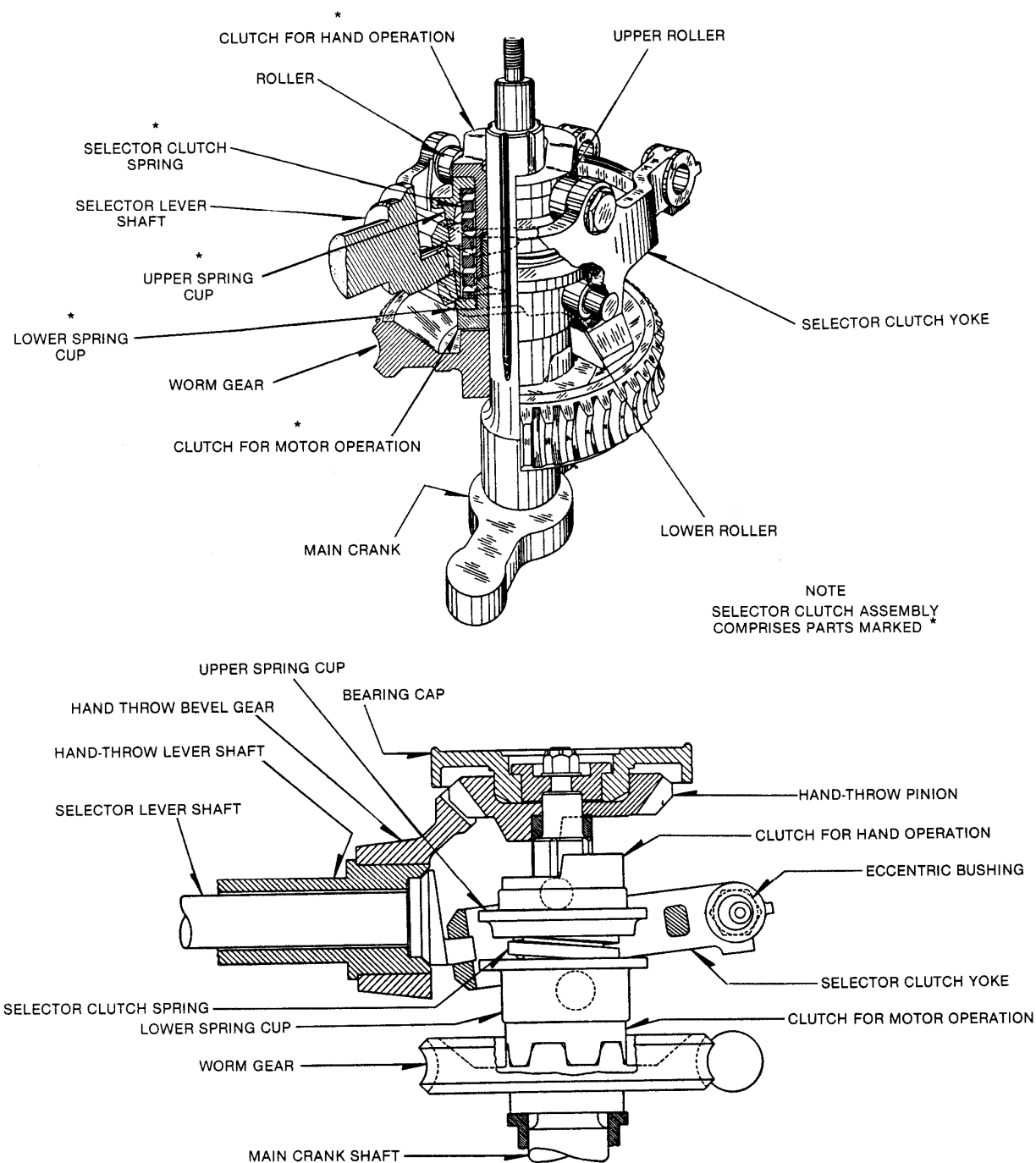


Figure 3-14. Sectional Views of M-23A Dual-Control Mechanism

Operation of the selector lever out of the motor position also actuates a pair of motor cutout contacts to open the motor circuit and in some cases to control a line circuit. The cutout contacts are mounted in the circuit controller compartment and are operated by a spring-return push rod projecting into the gearbox. This push rod is shifted toward the circuit controller by the action of a cam ledge on the selector clutch yoke engaging an adjustable rocker arm as shown in Figure 3-15.

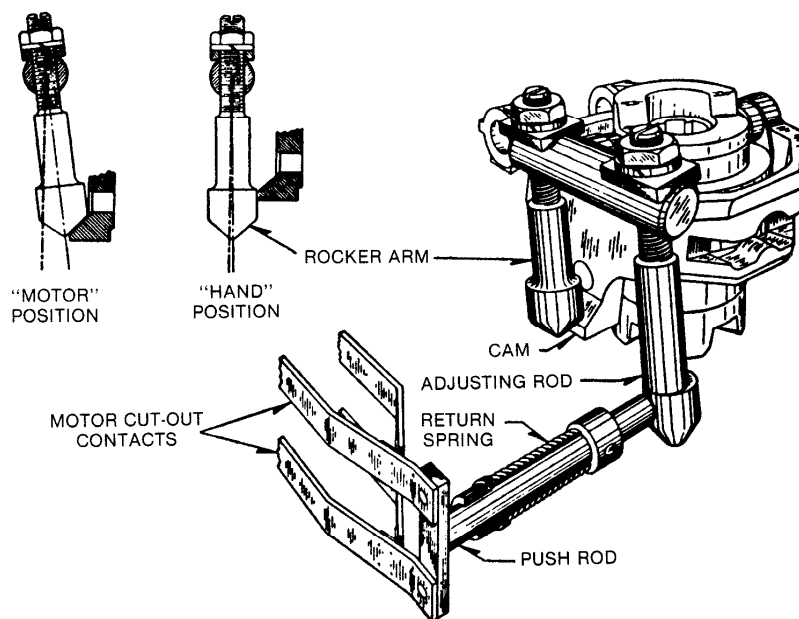


Figure 3-15. Motor Cutout Contact Assembly (M-23A and M-23B Machines)

3.7.2. M-23B Mechanism

The mechanical difference between M-23A and M-23B mechanisms is the hand-throw pinion, see Figure 3-16. The single tooth on the hub of the hand-throw pinion for the M-23B mechanism is of shorter arc than that for the M-23A, thus introducing sufficient lost motion between the pinion and the selector clutch to permit full stroke of the hand-throw lever (and thus the switch points) without moving the slide bar far enough for the locking dogs to engage the lock rods and, thereby, lock the switch points. The travel of the main crank is ample, however, to lock the switch-operating bar against back thrust.

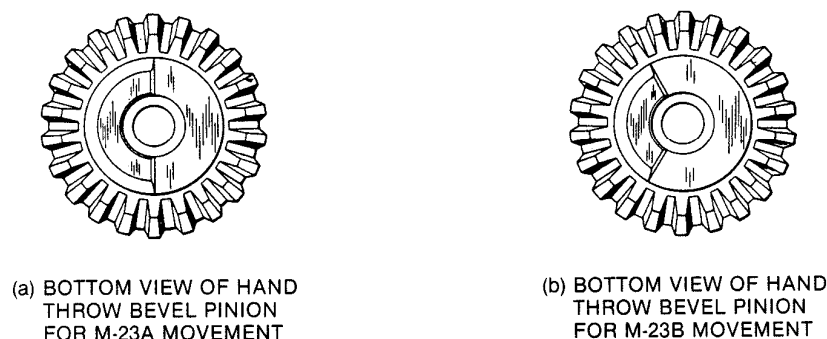


Figure 3-16. Hand-Throw Bevel Pinions for M-23A and M-23B Switch Machines Lever Interlock

The hand-throw and selector levers are interlocked by means of a steel ball and suitable recesses in the lever hubs, to prevent operation of the hand-throw lever unless the selector lever is in the HAND position, and also to prevent return of the selector lever from its HAND position unless the hand-throw lever is in one or the other of its full-stroke positions. The interlock can also be assembled to require that the hand-throw lever always be returned to Normal before the selector lever can be returned from its HAND position.

Details of the interlock are illustrated in Figure 2-9 and described in section 2.9. Moreover, it is possible to apply the selector lever to its shaft in either of two ways, 180 degrees apart, so as to have the MOTOR position of the selector lever toward either the motor end or the circuit controller end of the machine for both right-hand and left-hand assemblies.

3.8. Motor

3.8.1. Motors Available

Two 20 VDC and two 110 VDC motors are available. The 20-VDC motors are used on switch machines with gear ratios of 360:1 and 528:1. The 110 VDC motor is used on switch machines with gear ratios of 189:1 and 360:1.

For low voltage motors, under the most adverse conditions of load, temperature, and battery voltage, the. Voltage at the battery terminals should not be less than 20 VDC. 110 VDC motors should have not less than 85 volts at the motor terminals. The voltage at the motor terminals should be measured with the clutch slipping. Refer to Section 5.5.5.3 for information on the adjustment to slip the clutch.

3.8.2. Overload Protection

The standard plug-in type relay for the overload protection of DC switch machines is the Style PN-150SO relay.

This relay is used in conjunction with the style PN-150BM switch control relay and the style PP-151 magnetic stick relay for overload and short circuit protection.

Where shelf mounting relays are used, overload protection may be obtained for the DC machines by use of the OR-11 overload relay, and the DP-25 relay for switch control.

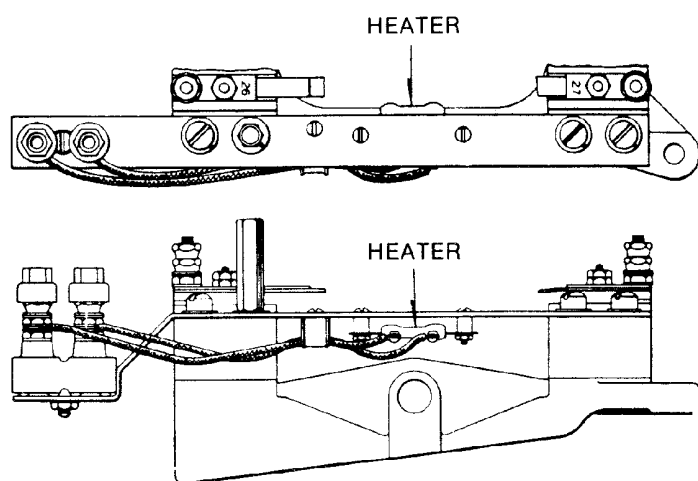
In ordering a switch overload relay, the current at which the clutch is set to slip or the gear ratio of the machine and the type of the machine with which it is to be used should be specified. The gear ratio is stamped on the switch machine name plate. The thermal resistors of these relays are selected to give proper operation for the value of current at which the clutch slips with overload.

3.9. Heaters

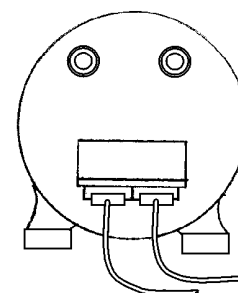
Fifteen watt heaters are available for use in the circuit controller and motor compartments. The heaters operate on 24 VDC, 115 VAC/VDC, or (dual element) 115/230 VAC/VDC power.

The heater for the controller compartment mounts at the end of the controller opposite the wire inlet as shown in Figure 3-17. It is held in place by the same four screws that fasten, the controller terminal board at that end. No additional holes are required and terminal space is available on the terminal board. Refer to Figure 2-6A and Figure 2-7A for wiring arrangements.

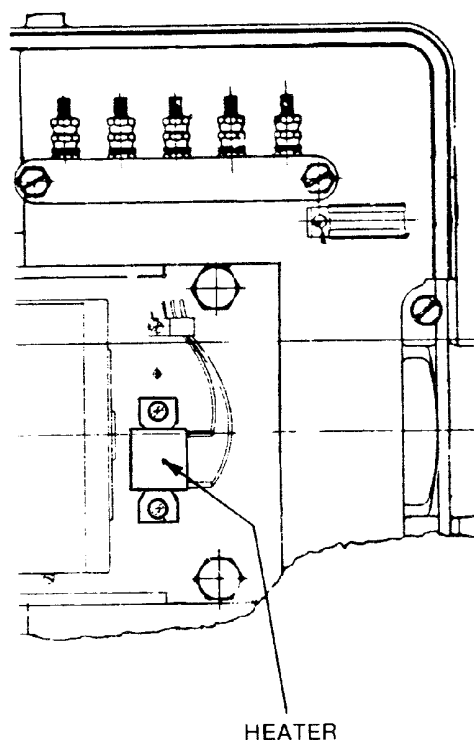
The heater for the motor compartment is mounted on the motor assembly cradle as shown in Figure 3-17.



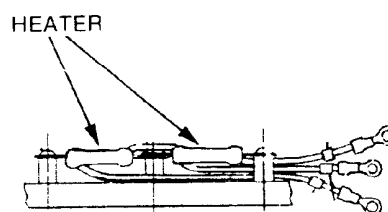
Heater for Circuit Controller



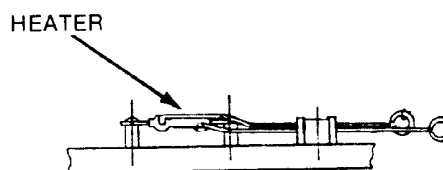
Heater for Motor Compartment "Gray" Motor Applications



Heater for Motor Compartment "Blue" Motor Application



15W-115/230 VOLTS



15W-115 VOLTS
OR
15W-24 VOLTS

Figure 3-17. Heaters for Circuit Controller and Motor Compartments

4. FIELD MAINTENANCE

WARNING

Disable the motor control circuit before beginning any work on a switch machine. If not, electrical shock or personal injury may result.

NOTE

The field maintenance procedures covered in the following paragraphs are those recommended by ASTS USA. The field maintenance policy of the customer will depend on actual operating experience and capability.

4.1. Preventive Maintenance

The following preventive maintenance procedures are intended to detect possible causes of switch machine failure before an actual failure occurs. Detection of such possible failures is accomplished by a scheduled maintenance process, whereby the switch machine is inspected, cleaned, lubricated, and performance-tested in the field on a periodic basis. The preventive maintenance procedures outlined herein ensure that all switch machine functions are operational.

A recommended schedule for performing preventive maintenance tasks is shown in Table 4-1. The actual time interval will depend on the customers own operating rules and/or experience.

Table 4-1. Preventive Maintenance Schedule

Interval	Functional Circuit or Equipment	Maintenance Action			
		Route Insp.	Clean	Lube	Perf. Test
Monthly	Switch Layout	X			
Semi-annually	Switch Machine	X			
Semi-annually	Switch Machine (Circuit Controller Compartment)		X		
Semi-annually	Switch Machine			X	
Monthly	Switch Machine				X

4.1.1. Inspection

Inspection is conducted in two areas: the switch layout area and the switch machine itself. Inspection consists of observing the appearance and integrity of the switch points, switch rods, connecting rods, possible switch obstructions, electrical connections, and the interior of the switch machine. A judgment is then made as to whether a potential or obvious faulty condition exists. When any faulty condition is observed, it is to be corrected immediately.

4.1.2. Switch Layout Inspection

Perform switch layout inspection as follows:

- a. Check that ties are well tamped to withstand vibration and strain caused by passing trains.
- b. Check that tie plates, tie straps, rail braces, and switch fittings are secure.
- c. Check that there are no signs of water accumulation around switch machine (proper drainage exists).
- d. Remove any material within layout that could obstruct switch movement.

4.1.3. Switch Machine Inspection

Perform switch machine inspection as follows:

- a. Remove covers from switch machine circuit controller, gearbox, and motor compartments.
- b. Using hand crank for M-3 or hand throw lever for M-23, operate switch back and forth as often as necessary and check for:

Proper and smooth operation of switch points without undue drag or spring and with points riding on all slide plates. Also check for switch point obstructions at this time.

Loose or damaged electrical connections.

Burned, frayed, or broken insulation.

Proper movement of switch machine main crank, slide bar lock box, switch-operating bar, circuit controller shaft, and circuit-controller point-detector connecting rods.

Excessive wear, lost motion, or accumulation of foreign or conductive material.

Excessive or unusual vibration and noise.

- c. Electrically operate switch machine and check for:
 1. Smooth movement of switch machine motor and gears; no binding etc., should be noticed.
 2. Conditions listed in step 'b', above.
- d. Check that there are no signs of moisture accumulation within switch machine compartments.

- e. During semi-annual inspections check for moisture in the compartments. If 3/8-inch pipe plugs are installed in two drain holes located in the crank case compartment, or slotted-head bolts with lock washers are installed in circuit controller compartment, remove plugs and allow whatever moisture is present to drain from compartment.

CAUTION

Where drain plugs are used, a moisture check should be made prior to anticipated freezing weather. A freeze-up of excessive moisture could result in improper switch machine operation.

- f. Reinstall plugs in drain holes.

NOTE

These pipe plugs should have been installed initially only if the switch machine is in a location where blowing sand or dust is troublesome; otherwise, drain holes should be open. During cold weather, periodically check that the holes are open.

- g. Check that motor control contacts, indication contacts, motor cutout contacts, and associated cams and linkages are clean and do not show excessive wear (Refer to Section 4.3).
- h. Check that all switch machine parts are properly and adequately lubricated (Refer to Section 5.6).
- i. Check that conduit between switch machine motor compartment and junction box is not crimped, nicked, cut, or otherwise damaged.
- j. Remove two screws securing access plate over motor commutator.
 - 1. Check that commutator is smooth and clean.
 - 2. Check that commutator brushes are free in their holders and are not excessively worn.

4.2. Cleaning

Extensive cleaning of the switch machine is not required. However, it is important that the circuit controller compartment be cleaned at the time of inspection to ensure proper electrical operation. Clean the circuit controller compartment as outlined in Sections 4.2.1 and 4.2.2.

Field Maintenance

4.2.1. Equipment/Materials Required

The following cleaning agents and materials are required to clean the circuit controller compartment:

- a. Water-based degreaser
- b. Lint-free cloths

4.2.2. Procedure

Clean the circuit controller compartment as follows:

- a. Dampen a lint-free cloth with household degreaser and wipe motor control, indication, and motor cutout contact springs free of any accumulated dirt. Dry with a clean, lint-free cloth.
- b. Repeat step 'a' for motor control segments, indication cams, yoke, operating levers, and point detector connecting rods, crank, and crank springs.
- c. Dry with a clean lint-free cloth.

NOTE

If the contact springs, motor control segments, or indication cams show any signs of pitting, corrosion or general deterioration, they must be replaced. Refer to Section 5.

- d. Lubricate cleaned areas per instructions provided in Section 5.6.

4.3. Lubrication

After the switch machine has been inspected and cleaned, it must be lubricated to ensure optimum operation. Refer to Section 5.6.

4.4. Switch Machine Performance Test

Conduct a performance test on the switch layout(s). The performance test should be done in accordance with customer's operating rules. The test should include mechanical operation of the switch mainline, and electrical tests of power distribution and switch control and indication circuits. Erratic or faulty operation and/or indications should be promptly referred to the proper authority for corrective action.

4.5. Corrective Maintenance

Field-level maintenance for the M-3, M-23, and M-23switch machines consists of:

- a. Friction clutch adjustment

- b. Switch machine to switch adjustment
- c. Motor control contacts adjustment
- d. Indication contacts adjustment
- e. Motor cutout contacts adjustment

4.5.1. Friction Clutch Adjustment

The switch machine friction clutch (Figure 5-1) must slip at just the right amount of torque. This torque must be more than adequate to carry the switch machine's operational loading during the driving of the switch points. At the same time, to transmit this torque, the friction clutch should not be so tight as to prevent protection of the mechanism from shock.

To check the friction clutch adjustment, refer to Section 5.5.5.3.

CAUTION

Friction disks must be kept free of oil, otherwise motor may be damaged due to excessive clutch slippage. If contamination occurs, friction disks must be replaced.

NOTE

If clutch discs are oily and it is found that oil is entering along the shaft, it is recommended that the felt washer and oil seal be renewed in the clutch housing as described in Section 5.5.5.1.

4.5.2. Switch Machine to Switch Adjustments

If it is necessary to readjust the switch machine refer to Section 2, Installation and Adjustments, Sections 2.3, 2.4, and 2.5.

4.5.3. Motor Control Contacts Adjustment

Refer to procedures provided in Section 5.5.6.1.

4.5.4. Indication Contacts Adjustment

Refer to procedures provided in Section 5.5.6.2.

4.5.5. Motor Cut-Out Contacts Adjustment

Refer to procedures provided in Section 5.7.2

4.6. Repair Procedures

Repair of the switch machine in the field consists of removing and replacing the motor brushes and major switch machine assemblies. It is not recommended that major overhaul or repair to the machine, requiring disassembly to the component part level, be done in the field. The switch machine should be removed from service and sent to the ASTS USA service or repair shop for this level of repair.

To remove the switch machine from service, refer to Section 2, Installation and Adjustments, and reverse the order of the steps listed. To remove and replace the brushes and major assemblies, remove and replace:

- a. Motor Brushes – Refer to Sections 5.4.1 and 5.5.3.
- b. DC Motor – Refer to Sections 5.4.2 and 5.5.4.
- c. Friction Clutch Assembly – Refer to Sections 5.4.3 and 5.5.5.
- d. Circuit Controller – Refer to Sections 5.5.5 and 5.5.6.

5. SHOP MAINTENANCE

5.1. Special Tools

Maintenance tools for M-3, M-23A, and M23B switch machines are listed in Table 5-1. Ordering reference for complete set of tools is X296406-001, Drawing 012764-0001.

Table 5-1. Maintenance Tools

Maintenance Tools for M-3, M-23A, and M-23B Switch Machines
6" Screw driver, slotted
10" Screw driver, slotted
6" Slip joint pliers
12 oz. Machinist hammer, ball peen
Insulated socket wrench, 1/2"
Adjustable Crescent wrench
10" Adjustable Crescent wrench
Set hex. Sockets
Ratchet wrench, 1/2" drive
Extension bar, 1/2" drive, 10" long
Special pin wrench (for clutch housing packing gland)
Thin head flat wrench (1-5/32" opening)
Allen wrench – 3/16" Hex.
Clutch assembly gauge, (hand/motor clutch)
Basket Wrench, 2-1/16" open-end (ASTS USA M322680) or box wrench (ASTS USA J49124401)

5.2. Cleaning

All major mechanical parts should be thoroughly cleaned to remove accumulation of dirt, grease and grime. Use only appropriate cleaning agents for the material being cleaned and follow manufacturer's recommendations for use.

CAUTION

Electrical components, such as the motor, heaters, wiring harness, or circuit controller should never be immersed in cleaning solution, otherwise damage to these parts will occur.

5.3. Inspection

After cleaning, carefully check case, cover, and other structural components for hairline cracks, breaks, weak points or any other signs of physical damage. During disassembly, carefully check each part for signs of damage. Replace any part found to be defective.

5.4. Disassembly

5.4.1. Removal of Motor Brushes

Refer to Figure 6-1 and Figure 6-2.

NOTE

When replacing motor brushes, both brushes should be replaced.

- a. For “Blue” Motor Applications (Motors BA-3640-4418-56C, BA 3636-4419-56C, BA3640-4420-56C with external brush covers, Type B):

Remove motor compartment cover (40). Remove motor brush/commutator covers by removing two screws on each side of cover. Lift and push to release spring holder. Remove motor brush from case. Repeat for the other brush.

- b. For “Gray” Motor Applications (Motors D-422305X6432, D-42206X6532, and D422307X6632 with brush band cover, Type A)

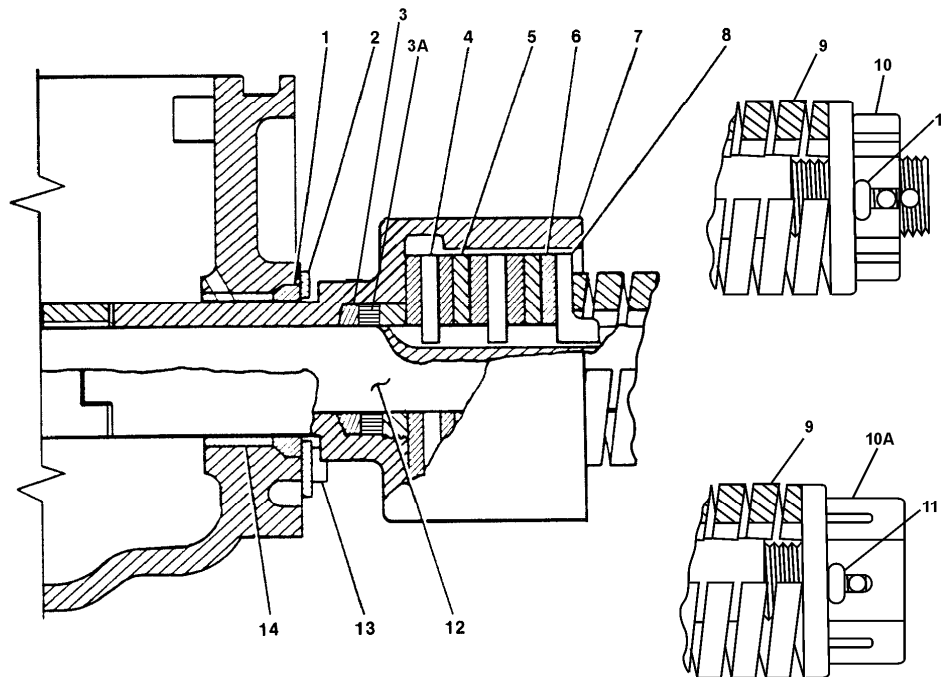
Remove motor compartment cover (40). Loosen brush/commutator cover and slide to allow access to brushes. Loosen brush terminal screw and remove brush lead. Retract brush spring and remove brush. Repeat for other brush.

5.4.2. Removal of Motor

Refer to Figure 6-1 and Figure 6-2. Remove motor compartment cover (40). Tag and remove wires attached to connections at motor’s end (closest to conduit outlet). Position wiring harness out of the way. Remove two 1/2-13 x 2” hex head cap screws (47, Figure 6-1; 46, Figure 6-2) at rear of motor’s mounting bracket (commutator end). Remove two associated 1/2” plain lock washers. Lift motor assembly (4) up and pull towards conduit outlet until pinion gear on motor shaft is clear of motor opening. If required, remove pinion from shaft and motor from bracket using Allen wrenches.

5.4.3. Removal of Friction Clutch Assembly

Refer to Figure 5-1. Remove cotter key (11) from clutch adjusting nut (10). Remove clutch adjusting nut (10) from worm shaft. Remove clutch spring (9). Remove two cap screws (13) securing plate. Remove plate and gasket. Pull clutch housing/tubular neck (7) out of engagement with gear hub. Continue to pull until tubular neck is clear of opening in gearbox, exposing worm shaft.



Item No.	Description	ASTS USA Part No.
1	Gasket	M245192
2	Plate	M147400
3	Felt Washer	J047335
3A	Oil Seal	J7900260003
4	Clutch Plate	M146574
5	Clutch Plate	M146573
6	Clutch Disk	M146650
7	Clutch Housing	M172752
8	Clutch End Plate	M146575
9	Clutch Spring	M239322
10	Clutch Adjusting Nut M-3	M286615
10A	Clutch Adjusting Nut M-23	M438402-001
11	Cotter, 3/16 x 2" (Tin Pl.)	—
12	Worm Shaft	M286612
13	Cap Screw, 1/4-20 x 3/4" Hex Hd. (Tin Pl.)	—
14	Bushing	J790004

Figure 5-1. Friction Clutch Assembly

5.4.4. Removal of Circuit Controller

Refer to Figure 6-1. Remove circuit controller cover (36). Tag and remove wires attached to circuit controller terminals and heater. Position wiring harness out of way by removing the four wire clamps, screws, and lock washers. Remove the two screws (6) and lock washers attached to the feet of the circuit controller nearest the motor compartment. Remove the two screws (74),

lock washers and plate (9) located between the point detector cranks. Lift and remove circuit controller from compartment. If further disassembly is required see Figure 6-5.

5.4.5. Gearbox Removal, M-3

Refer to Figure 6-1. Disconnect pull knob from yoke. Remove the two screws located on either side of the cotter key (70) that links the push rods and the motor cutout contact controls. Remove push rod (27) by holding it at the end nearest the motor compartment and pulling it until the opposite end clears the shaft (31). Remove push rod by lifting and pulling it until the pin at the other end clears the hole in the side of the housing. Remove the four screws (134) that secure the gearbox to the base. Lift gearbox from base of switch machine. If further disassembly of the gearbox is required see Figure 6-3.

NOTE

Before proceeding with further disassembly, the maintainer should be thoroughly familiar with the information and illustrations found in Sections 1 and 3. These illustrations will aid in final disassembly of the switch machine.

5.4.6. Removal of Main Crank

For all three machines (M-3, M-23A, and M-23B), it is necessary to take out the main crank through the bottom of the machine. To do this, the bottom cover and the wear plates supporting the operating bar must be removed first, allowing the operating bar and crank roller to drop down. Then rotate crank (turn friction clutch by hand) until bottom end is crosswise of machine. Unscrewing the nut at the top of the main crank shaft will then permit the crank to drop out through the bottom. Removal of the main crank will release the worm gear and the slide bar.

5.4.7. Removal of Selector Clutch

For dual-control machines (M-23A and M-23B), removal of the selector clutch and associated parts can readily be understood from the information given for changing from R.H. to L.H. assembly, or vice versa. However, when reassembling the selector clutch, note that all its overall height, including top and bottom teeth, is 5-9/32 inches max. to 5-17/4 inches min. This dimension is adjustable by turning the top and bottom parts of the clutch assembly with respect to each other. This can best be done by inverting and placing “hand” portion on the crank splines and turning “motor” portion with screw driver or bar in motor clutch teeth. Splines in both parts must be aligned to permit reassembly. For “timing” of the dual-control gearing upon reassembly, see Section 5.5.2.

5.4.8. Removal of Worm Shaft

To remove the worm shaft, it is necessary to take the gearbox off the base casting, otherwise the end of the shaft would strike the wall of the circuit controller compartment.

The slide bar can be removed through the motor compartment, after first removing the lock box and the motor.

5.4.9. Final Disassembly

After removing all major subassemblies per the above paragraphs, continue to disassemble the remaining components (refer to Figure 6-1 or Figure 6-2 and associated parts list for parts location and identification). Disassemble only to the degree necessary to repair the machine.

5.4.10. Gearbox, Dismantle, M-23A and M-23B

Refer to Figure 3-12 and Figure 3-13.

- a. To remove covers for gearbox and motor compartment and use as receptacles for parts removed. Place hand-throw lever in Normal position and selector lever in MOTOR position.
- b. Remove 1/2"-13 bolts A1, A2, A3, and A4, securing top bearing C, yoke support H, lever support K, and lever shaft bearing M, respectively.
- c. Remove castellated nut B1 and washer B2 from top of main crank and lift top bearing C from dowel pins carefully to prevent bending. Remove the rectangular key C1 (Figure 3-12) from top bearing bushing C2, hand-throw pinion D and spacing collar E on top end of crank. Lift hand-throw lever to vertical position and remove set-screw F1 from hand throw bevel gear F. Remove lever assembly and lift out hand-throw bevel gear.
- d. Remove 1/2-13 x 5-1/2" bolt G, securing yoke eccentric bushings G1 and then remove yoke support H. Positions of eccentric bushings should be noted, and care should be taken to avoid changing their position when removing the bolt.

5.5. Assembly

5.5.1. Reinstallation of Gearbox, M-3

Refer to Figure 6-1. Place gearbox onto switch machine base. Align mounting holes in gearbox with holes in the base. Install four screws (134). Install push rod by inserting the pin into the housing and lowering the push rod. Install push rod (27) by sliding the cutout contact end through the shaft (31). Align the holes at the end of the push rod with their respective swivels and install the two screws. Mount and adjust knob to yoke.

5.5.2. Gearbox, Reassemble Dual Control M-23A and M-23B (RH to LH; LH to RH)

Refer to Figure 3-12 and Figure 3-13.

- a. Transfer the yoke support H to the other hub, rotate yoke 180 degrees, and reapply eccentric bushing bolt G without disturbing eccentric bushing positions.

- b. Reapply lever assembly to the hub on opposite side of gearbox, with shaft splines entering hand-throw gear F and with eccentric pin P on selector shaft entering the slot on the end of the yoke. With hand-throw lever vertical, reapply set-screw F1 in hand-throw gear F. Reapply 1/2"-13 bolts A2 to secure yoke support H and replace the two top bolts A4 to hold lever shaft bearing M in place.
- c. In order that "Motor" position of selector lever will be toward motor end of machine, as indicated for standard assemblies in Diagram A, B, C, or D of Figure 2-9, selector lever and lever interlock must be reassembled 180° from original position on shaft, as follows:
 1. Remove hex nut and washers from end of selector lever shaft and slide selector lever and lever support K from the shaft. Be careful not to lose steel ball in lever support.

NOTE

If stop screw is used in hub of hand-throw lever, it will be necessary to remove this lever also and interchange stop screw and cap screw (refer to Figure 2-9). Replace hand-throw lever and fasten in place with clamping bolt.

2. Reassemble lever support K with hole for the ball on motor side of shaft. Insert steel ball and reassemble selector lever on shaft so that lever will be 180 degrees from its original position. (Stop screw, if used, may require positioning hand-throw lever to align recess with hole in lever support so that ball will not interfere when selector lever is applied.) Replace hex nut and washers on end of shaft to hold selector lever in place, and fasten lever support K with the two 1/2" – 13 bolts A3, which also secure the bottom of the lever shaft bearing.
3. Operate selector lever to motor position (i.e., toward motor end of machine) and check that it moves yoke N down.
4. Interchange MOTOR and HAND nameplates on selector lever to correspond with these lever positions.

WARNING

The MOTOR and HAND nameplates must be interchanged on the selector lever to correspond with the lever positions to avoid possible physical injury.

- d. Reassemble collar E (with chamfer down) on top of crank and, with hand-throw lever vertical, apply hand-throw bevel pinion D, engaging tooth marked R (for right-hand assembly) or L (for left-hand assembly) with punched marked master tooth space on hand-throw gear F. Carefully place hand-throw lever in Normal position. Be sure that bevel pinion remains in line. With selector lever in MOTOR position, rotate friction clutch housing so that motor clutch teeth are fully engaged.

- e. Reapply top bearing assembly and secure with hold down bolts A1. (Motor cutout push rod should be held back to clear the adjusting rod until top bearing is down.)
- f. Apply top bearing bushing C2, rectangular key C1, washer B2, and tighten castle nut B1 firmly, then back off to nearest cotter hole and apply cotter, after operating machine by hand-throw lever to be sure that mechanism does not bind.
- g. Check adjustment of motor cutout push rod. Contacts should open when end of selector lever has been raised approximately 6" from the horizontal motor position.
- h. Readjust both yoke eccentric bushings as described in Section 5.7.3, then secure by tightening bolt G firmly.
- i. Check that machine can be operated by power, and also that it shifts to hand-throw operation from both normal and reverse positions.
- j. Check that all bolts are drawn down tightly on lock washers and that all cotters are in place.
- k. Reinstall covers.

5.5.3. Reinstallation of Motor Brushes

Refer to Section 6.7. Before installing the motor brushes, check that the motor commutator is smooth and free from grease and oil. To dress the commutator, use a fine grain commutator stone or a piece of No. 00 sandpaper. Never use emery cloth for cleaning the commutator or brushes. These commutators must not be undercut.

- a. For "Blue" Motor Machines (Motors BA-3640-4418-56C, BA 3636-4419-56C, BA3640-4420-56C with external brush covers, Type B)

Fit brushes to commutator, using No. 00 sandpaper. Install motor commutator brush in holder. Install spring hold down by pushing into slot beside brush and hooking it over the end of the brush holder. Repeat for other brush. Check that motor commutator brushes are free in the holders. Install motor brush/commutator covers with two screws on each cover. Install motor cover (40). Operate switch machine motor to determine if brushes are properly installed.

- b. For "Gray" Motor Machines (Motors D-422305X6432, D-42206X6532, and D422307X6632 with brush band cover, Type A)

Brushes are provided with radius to fit commutator, therefore sanding of brushes is not recommended. Retract brush hold down spring, insert brush into holder, and release spring. Terminate brush lead to terminal. Repeat for other brush. Position brush/commutator cover over access holes and tighten screws. Install motor compartment cover. Operate switch machine to verify brushes are properly installed.

5.5.4. Reinstallation of Motor

Refer to Figure 6-1 and Figure 6-2. Lower motor bracket onto base of switch machine so that pinion end of motor is inserted through motor shaft opening. Position motor so that pinion is mated properly with reduction gear. Align mounting holes in motor bracket at commutator end with holes in base of switch machine. Insert two 1/2 – 13 x 2” hex head cap screws (47, Figure 6-1; 44, Figure 6-2) and two associated 1/2” plain lock washers in motors mounting bracket (commutator end). Reattach wires to motor connections. Replace motor cover (40).

5.5.5. Reinstallation of Friction Clutch Assembly

Refer to Figure 5-1. Before assembly, check that the friction discs (6) are free of oil. If clutch discs are oily and it is found that oil is entering along the shaft, it is recommended that the felt pad and oil seal be renewed in the clutch housing. Refer to Section 5.5.5.1. If the felt washer and oil seal are not to be replaced, continue with Sections 5.5.5.2 and 5.5.5.3.

5.5.5.1. Instructions for Replacing Felt Washer and Oil Seal in Clutch Housing

Refer to Figure 5-2. Measure the length of clutch spring before disassembling and record this dimension as information for reassembling. Swing terminal board out of the way, remove the adjusting nut and clutch spring, and slide the clutch housing off the shaft. Remove the discs and plates and take out the small lock screw, using the special tool, Pc. No. N173641, to remove the packing gland nut.

Remove the old packing and clean the shaft and the inside of the clutch housing by washing with a non-flammable grease solvent. Apply a new felt washer (J047335) and oil seal (J7900260003) to the housing recess and assemble the packing gland nut. Using the spanner end of the special wrench, pull down nut only until it is flush with the bottom of the clutch housing. Then the locking screw should be inserted and drawn down securely. Coat rubbing surfaces of packing rings with gearbox lubricant. Assemble housing to the shaft. Clean lubricant from shaft surface inside the clutch space.

Old fabric discs should be discarded and replaced. Old clutch plates should be thoroughly cleaned in a non-flammable grease solvent to remove any accumulation of lubricant, and then reassembled as shown. It will be noted that a fabric disc goes in the bottom of the housing, and the first metallic disc is one with teeth engaging the shaft.

5.5.5.2. Assembly of Friction Clutch

Refer to Figure 5-1. Install gasket (1) in gearbox opening. Install plate (2) with two 1/4-20 x 3/4” hex head cap screws (13). Align tubular neck of clutch assembly and worm shaft (12). Insert tubular neck of clutch assembly partially over worm shaft and through gearbox bushing. Align three finger end of tubular neck with matching slots in clutch gear hub. Push tubular neck into gear hub slots until neck/hub is in clutch gear hub. Push tubular neck into gear hub slots until neck/hub is solidly engaged. Install the following items on the worm shaft:

- a. Insert clutch disc until it sits against inner wall of clutch housing.

- b. Insert clutch plate in groove on worm shaft until it mates with clutch disc.
- c. Insert another clutch disc.
- d. Insert another clutch plate.
- e. Repeat steps c and d for three remaining clutch discs and two remaining clutch plates.
- f. Insert clutch end plate on worm shaft.

Slide clutch spring over worm shaft until it rests against clutch end plate. Install clutch adjusting nut on worm shaft. Tighten clutch adjusting nut in accordance with friction clutch adjustment procedures. Recheck this adjustment after a brief wearing-in period.

5.5.5.3. Friction Clutch Adjustment

Friction clutch adjustment should be checked to be sure the clutch slips at a torque which will protect the mechanism from shock, yet adequate to carry usual operating loads.

Also, for proper operation of the overload relay the clutch must be maintained to slip at a current value above the minimum current rating of the relay or no protection will be obtained.

NOTE

In addition to a temporary jumper across the binding post of the pick-up coil on the overload relay called for in the maintenance and adjustment section of this manual, all 6-1/4 amps Fusetrons on the 110 VDC side of a bridge rectifier (if used) should also be temporarily jumpered out.

To check the friction clutch adjustment, apply a temporary jumper across the binding posts of the pick-up coil on the overload relay (See NOTE) and insert an ammeter in the motor circuit as follows: Connect negative ammeter lead to binding post A on switch machine terminal board and positive ammeter lead to binding post 5 or 10, depending upon switch point position. The average peak current taken by motor with clutch slipping should be within 10% of the nominal value shown in

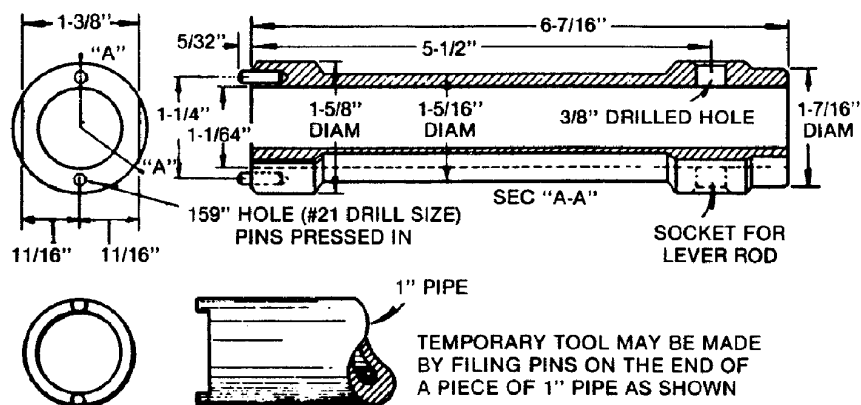
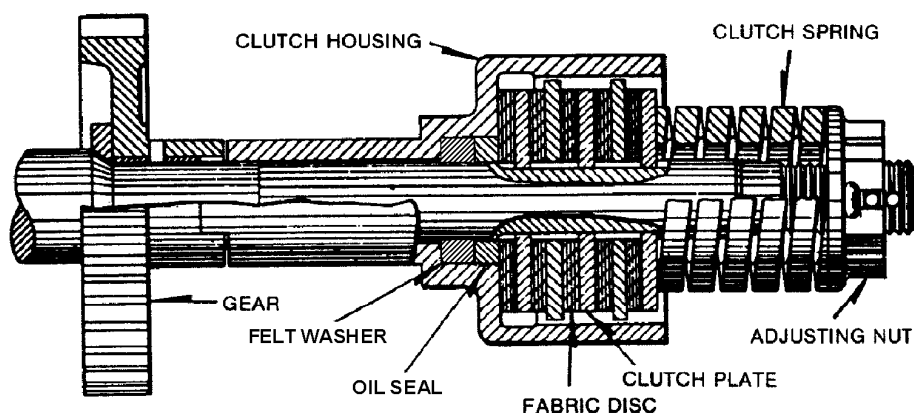
Table 5-2 for the particular motor and gear ratio involved. The motor current must be checked in both directions. If necessary, remove cotter and screw the friction clutch spring adjusting nut (Figure 5-2) in or out to obtain desired current. After tests are completed, remove temporary jumper from overload relay.

Table 5-2. Adjustment to Slip the Clutch

Motor	Gear Ratio	Adjust Clutch to Slip at Amps.*
110 VDC	189:1	14
20 VDC	528:1	12
20 VDC	360:1	23**
110 VDC	360:1	10

* The motor current listed for gear ratio 189:1 must be checked in both directions and set for a minimum of 14 amps. A variance of about 1 to 3 amps may exist due to mechanical alignments and motor characteristics. Piece numbers N451160-0504 and -0505 have the clutch set to slip at 14 amps.

** Gray motor machines are shipped from the factory set to slip at 20 amps. The clutch may be adjusted to slip at 23 amps for field applications, if desired.



(PC 173641)

Figure 5-2. Friction Clutch Assembly and Special Wrench for Packing Gland Nut

5.5.6. Reinstallation of New or Rebuilt Circuit Controller

NOTE

It is necessary that the lock box be toward the motor end before installing a new or rebuilt controller into the switch movement. This is done by operating the movement to the end of its stroke using the hand crank (M-3) or hand-throw lever (M-23A/M-23B).

Refer to Figure 6-1 and Figure 6-2. Using the hand crank (M-3) or hand-throw lever (M-23A or M-23B), operate the movement to the end of its stroke. This places the slide bar and lock box toward the motor. Lower circuit controller into circuit controller compartment. Align mounting holes. Reinstall the two screws (8) and 3/8" lock washers in the holes nearest the motor compartment. Reinstall the plate (9), two 1/2-13 x 1" hex head cap screws (6), and two 1/2" lock washers between the point detector cranks. With wire harness within the clamps, reinstall the four wire clamps with four 5/16 x 1-5/8" machine screws and four 5/16" lock washers.

Refer to tags and reattach harness wires to correct circuit controller terminals and heater connections. Tighten all screws securely and be sure the gearing on the circuit controller meshes properly with the crank teeth on the movement lock box. See that the circuit controller shaft assembly is in the angular position agreeing with that shown in Section Y-Y of Figure 6-5 checking specifically the relation shown in the schematic diagram for setting of segments for contacts 24-25 and 26-27. This should place the cam block (Item 57) of main shaft gear (Item 56) in the position shown. The next move should rotate the cam block away from, rather than into, the pinion gear (Item 59). Install at least three of the circuit controller frame hold-down bolts, but do not tighten. By use of the hand crank or hand throw lever, operate the movement slowly, checking that the cam block moves in the proper direction. Before tightening circuit controller frame hold-down bolts, check that full stroke controller shaft rotation gives symmetrical contact relationship at both ends of the stroke. Shift clear tooth engagement, if necessary, to obtain this condition. Install and tighten all hold-down bolts.

5.5.6.1. Motor Control Contacts

The motor control contacts are set at the factory to ensure that the switch machine is locked in accordance with AREMA specifications. Ordinarily, readjustment will not be required as long as the assembly remains undisturbed. If an adjustment is required, proceed as follows:

- a. Clean and degrease the contacts with a suitable cleaner.
- b. With the machine in an unlocked position, insert a 1/2 (+0, -0.01) x 2 x 24" steel bar into the lock rod slot. Turn the clutch housing by hand until the lock dog bears against the bar. In this position, the machine is fully locked.
- c. Connect an ohm meter or test light across one of the appropriate control contacts.

- d. Loosen the nuts which hold the “V” end of finger F1 and slide the finger in or out until a point where any additional cam rotation will open the contact. Retighten the nuts. When a 15/32 (+0”–0.01) x 2 x 24” steel bar is used for the aforementioned test, the contacts should be open.
- e. Repeat the procedure for the other three motor control contacts. Check to see that adjacent control contacts open simultaneously.

Contact finger F1 should be adjusted to bear against the segment with 2 to 2-1/2 lbs. pressure while the finger F2 is held clear. Adjust finger stop F1a to have $1/32 \pm 1/64$ ” clearance from finger F1 when the latter is riding the segment. Adjust finger F2 to bear on finger F1 with 1-3/4 to 2 lbs. pressure when finger F1 is on the segment.

Adjust stop F2a to clear finger F2 by $1/32 + 1/64$ ” min. When contacts are closed as shown in Sect. W-W and X-X, and to permit finger F1 to clear finger F2 by 1/16” minimum when contacts are open as shown in Sect. Y-Y and Z-Z. Adjust finger F3 to bear on the segment with 1-3/4 to 2 lbs pressure.

5.5.6.2. Contact Pressures and Clearances

Contact pressures and clearances must be in accordance with Sections P-P and N-N of Figure 3-7 and are to be obtained by the following procedure:

- a. With switch machine at end of stroke to enable roller to drop into cam notch, adjust reinforcing spring (N) by relieving tension with a spring bender to break away from the contact spring at a load of 8 to 11 pounds.
- b. Check clearance between cam and roller with roller in cam notch to see if it is 3/64 inch to 5/64 inch. If not, readjust reinforcing spring to obtain correct clearance and recheck reinforcing spring breakaway load to make sure it is not greater than 11 pounds or less than 8 pounds.
- c. Check that slotted ends of contact springs (M) are in alignment, bear evenly on fixed contact (W) and on short circuiting strip, and both contact springs of each pair make and break at the same time. It may be necessary to slightly bend the contact fingers to meet this requirement.
- d. Check 1/8 inch minimum dimension between end of indication contact spring (M) and short circuiting strip. Check 3/64 inch minimum clearances between spring (M) and fixed contact, and between spring (M) and short circuiting strip. No adjustment should be necessary to obtain these dimensions if spring (M) is made properly.
- e. With contacts at indicating position, check gap clearances at (Y) for 3/64 inch to 5/64 inch, and check contact pressure between indication contact spring (M) and fixed contact with spring scale at (X) to see if pressure is 1-1/2 pounds to 2-1/4 pounds. Adjust reinforcing spring breakaway load if necessary to meet these requirements and recheck to make sure it is not greater than 11 pounds or less than 8 pounds.

With contacts made against short circuiting strip check at front end of contact fingers with push scale for a load of 1-1/2 pounds to 4 pounds.

5.5.7. Assembly, Lever Interlock

The sectional views in Figure 2-9 illustrate the lever interlock assembly. It comprises recesses in both lever hubs and a steel ball carried in a hole in the lever support. In reassembling, BE CAREFUL TO NOT LOSE THE BALL when the lever is taken off.

As can be seen in the diagrams, the diameter of the ball is greater than the thickness of the wall of the lever support. Thus, with the selector lever in the MOTOR position as shown, part of the ball is held in the recess of the hand-throw lever and thereby prevents operation of the hand-throw lever. Reversing the selector lever aligns the ball recess in its hub to permit the ball to shift out of the recess in the hand-throw lever hub, thereby releasing the hand-throw lever. While the hand-throw lever is at any position between the ends of its stroke, the ball is held in the recess in the selector lever hub and thereby locks the selector lever.

The hand-throw lever hub has two ball recesses 180° apart so that at either end of the lever stroke one of the recesses will be aligned with the ball to unlock the selector lever. If it is desired to make it compulsory that the hand-throw lever be in the Normal position before allowing the selector lever to be operated, one of the ball recesses in the hand-throw lever must be plugged by the use of stop screw Pc. No. 14287186, as indicated in Figure 2-9.

When used, the stop screw must be applied to a particular recess in the hand-throw lever hub, as follows. With the hand-throw lever in the Normal position, the stop screw must be in the recess on the side of the shaft opposite to the side the selector lever is on when in its MOTOR position (see Figure 2-9).

The lever support can be assembled with the hole for the ball on either side of the lever shaft center. However, it must be assembled so that the hole for the ball is on the same side of the shaft as the selector lever is in for MOTOR position (see Figure 2-9).

As previously mentioned, the selector lever can be assembled on the square end of its shaft in either of two positions, 180° apart, so as to have the MOTOR position of the lever either toward the motor compartment or toward the circuit controller compartment. Machines are shipped from the factory with the selector lever assembled for MOTOR position toward the motor compartment. If the lever assembly is reversed in the field, the transfer must be made while the crank finger on the end of the shaft is at the bottom of its stroke to force the selector clutch down toward its motor position. Be sure to reassemble the lever support to shift the hole for the ball to meet the requirements in the preceding paragraph. Similarly if a stop screw is applied to one of the ball recesses in the hand-throw lever hub as previously described, it must be shifted so as to be on the side of the shaft opposite to that for MOTOR position of the selector lever.

5.6. Lubrication

Before leaving the factory all working parts of the machine except the worm gear compartment are well lubricated. Unpainted and unplated parts are coated with a special lubricant designed to protect these parts against corrosion until installation. This lubricant need not be removed since it will mix readily when new lubricants are added.

For best results, only lubricants complying with strict specifications are recommended. The recommended lubricants can be purchased in convenient quantities from ASTS USA.

Figure 5-3 and Figure 5-4 identify the areas of the switch machine that need lubrication. These points and the proper lubrication are further described in Table 5-3. The following steps present the general lubrication requirements for the switch machines.

- a. Apply pressure gun grease (ASTS USA Spec. M-7650-01)
 1. Point detector bar bearings (use gun on grease fittings).
 2. Operating bar wearing plates (use gun on grease fittings).
 3. Selector and hand-throw lever shaft bearings (use gun on grease fittings).
 4. Surfaces of slide bar and lock box and rack G, using brush or paddle for application (a heavy oil, viscosity 120-200, (SAE-140) may be used as an alternate on these surfaces).
 5. Circuit controller trunnions (use gun on grease fittings).
- b. Apply medium body motor oil viscosity 130°F 185-220 (SAE-30), to the following parts:
 1. Yoke bearings and point detector linkage.
 2. Spur gear journals (machines are equipped with Oilite bushings).
 - a. Holes in box casting.
 - b. Holes in reduction gears and in clutch gear.

NOTE

Oil should be applied sparingly to clutch gear bearing to prevent seepage through clutch shaft packing to the friction discs.

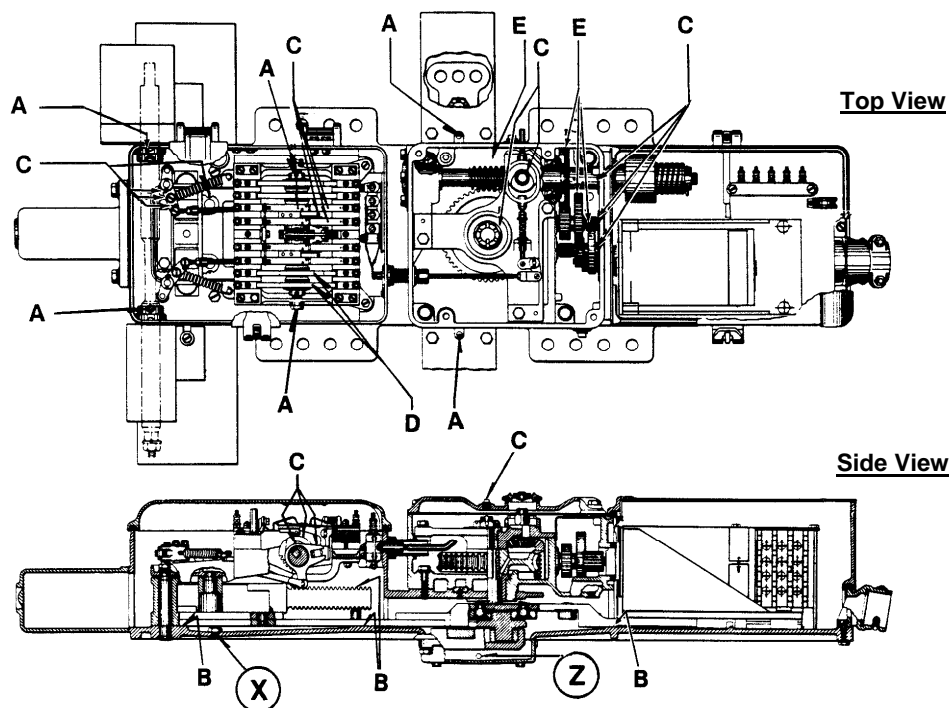


Figure 5-3. Lubrication Diagram for M-3 Switch Machine

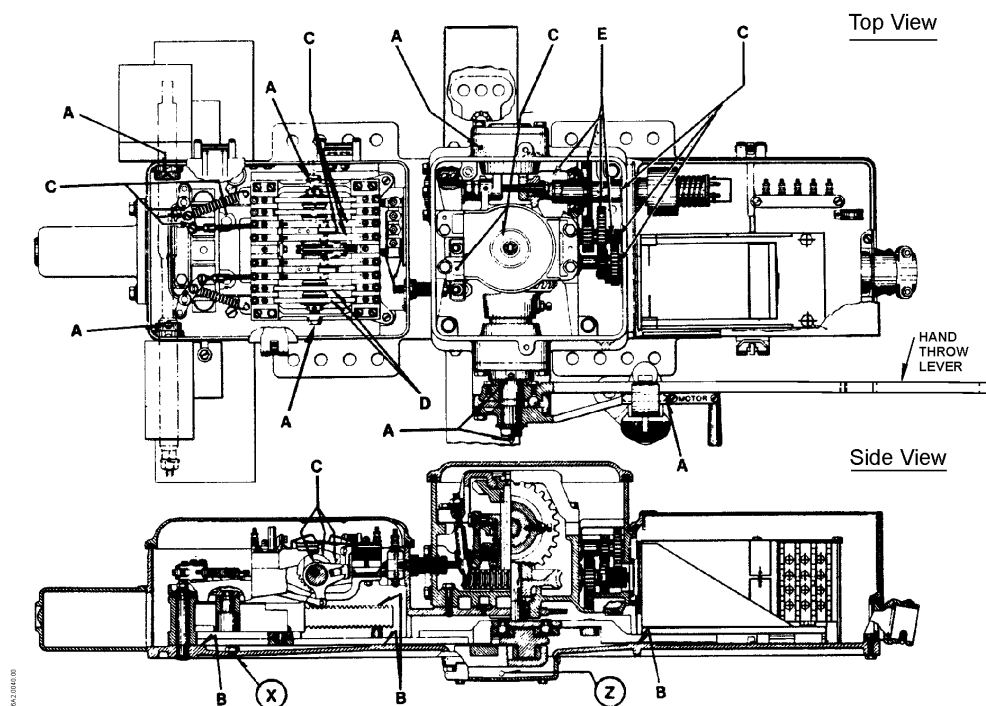


Figure 5-4. Lubrication Diagram for M-23A and M23-B Switch Machines

3. For M-3 machines only:
 - a. Main crank shaft – remove oil plug in top cover. Oil will collect in a recess and be led to shaft surfaces needing lubrication.
 - b. Linkage connections for motor cutout.
4. M-3, M-23A and M-23B machines – fill recess on top crank bearing.
- c. Apply a light oil (ASTS USA Spec. M-7610-02)
 1. To contact segments of indication circuit controller (segments and contact springs should be thoroughly cleaned before application).
 2. Sparingly to motor commutator if brushes chatter.
- d. From the container shipped with the machine, apply the gear lubricant (Spec. M-7652-3). This is a low-temperature all-weather lubricant that has little change in consistency with temperature variations. It will retain its lubricating properties at the highest temperatures encountered and not become so stiff at low operating temperatures as to require thinning. If sustained abnormally low temperatures are anticipated, a special lubricant may be ordered. Contact your salesman or the Engineering Department for an ordering reference number.

M-3, M-23A, and M-23B machines – Apply a light coat of gear lubricant to spur gear teeth. The gear lubricant must be packed well around the worm gear and the selector clutch in the worm gear compartment. It must be replaced as necessary to keep the worm gear covered.

CAUTION

Lubrication at proper intervals is essential to ensure proper equipment operation. **Do Not Permit Grease Or Oil To Enter Spring End Of Friction Clutch, Otherwise Friction Clutch May Malfunction.**

Regular and systematic lubrication is recommended; however, the lubrication interval depends on the operating frequency and the climate and location conditions, and therefore can be established from experience by the Supervisory Department.

Table 5-3. Lubrication Specifications for M-3/M-23A/M-23B Switch Machines

Point of Application	Type of Lubricant & ASTS USA Spec.	Known Products Complying With Spec	Method	Apply To	Remarks
A	Pressure Gun Grease Spec. M-7650-01	Alemite Solidified Oil #32 (Alemite Temprite Solidified Oil E.P. (Prime Mfg. Co)	Grease Gun	Grease Fittings	Apply until surplus is visible at edges of bearing
B	Either Pressure Gun Grease Spec. M-7650-01 OR Heavy Oil (Viscosity at 210F, 120 to 200)	Same as above	Gun or Paddle	Surface	
		Auto. transmission and rear end lubricant SAE. 140	Pour or Paddle	Surface	
C	Medium-Body Oil (Viscosity at 130F, 185 to 220)	Automobile Engine Oil SAE. 30	Oil Can	Bearings & Oil Cups	A few drops periodically as required
			Pour	Recess on top crank bearing	Fill recess periodically as required
D	Low Temperature Oil Spec. M-7610-02	Low Temperature Lubricating Oil (ASTS USA)	Oil Can	Surface	Apply very light film to all contact segments at frequent intervals after cleaning
E	Low Temperature Lubricating Oil Spec. M-7652-3	Lubriplate 5555 (Fiske Brothers Refining Co)	Pour	Spur Gear Teeth	Apply light coat to teeth as required
				Worm Gear Compartment	Pour in. Fill only to top of worm gear

5.7. Adjustments

5.7.1. Point Detector

Point detector rollers should be maintained to clear the small diameter of the point detector bar by not more than 1/32". If necessary, adjust the screwing eyebolts (19) (Figure 6-5) in or out [screws (67)] must first be removed).

Use point detector gauge N295326 to check latch operation in normal and reverse switch positions. See SM-5453 for instructions for usage of the point detector gauge. Add a sufficient amount of shims as required to enable latch to clear the top of the yoke in both switch positions and latch properly. Check indication contacts in latched positions to insure that they are open a minimum of 3/64".

5.7.2. Motor Cutout Contacts

See Figure 5-5 for a detail view of the motor cutout contact and actuator arrangement.

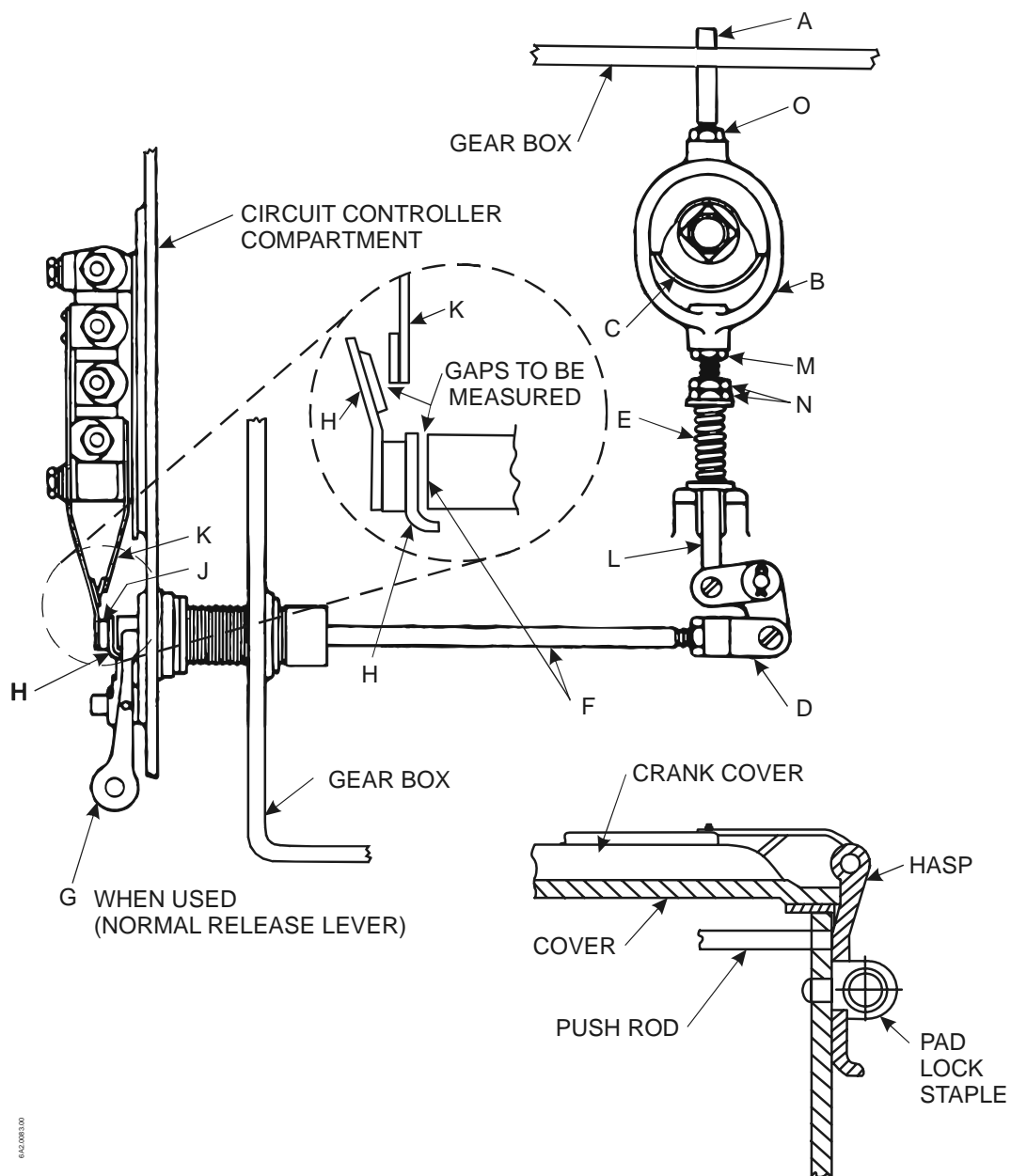
5.7.2.1. M-3 Switch Machine Motor Cutout Contacts Inspection

- a. Remove the circuit controller cover.
- b. Make sure the hand crank cover is closed.
- c. Inspect the gap between "F" and "H" of Figure 5-5. The preferred gap is 1/16". The gap cannot be more than 1/8".
- d. Open the hand crank cover and inspect the gap in detail "H" and "K" of Figure 5-5. The minimum gap should be 1/8". A larger gap is acceptable.
- e. For machines with latch release lever "G", close the hand crank cover so that the hasp engages the notch in the staple. The motor cutout contacts should be held open by the angle bracket "H" against latch release lever "G". Releasing the latch release lever "G" should close the contacts.
- f. If any of the above conditions are not met, the motor cutout linkage should be adjusted as per Section 5.7.2.2.

5.7.2.2. Motor Cutout Contact Adjustment:

Remove the gearbox cover removed and verify the following:

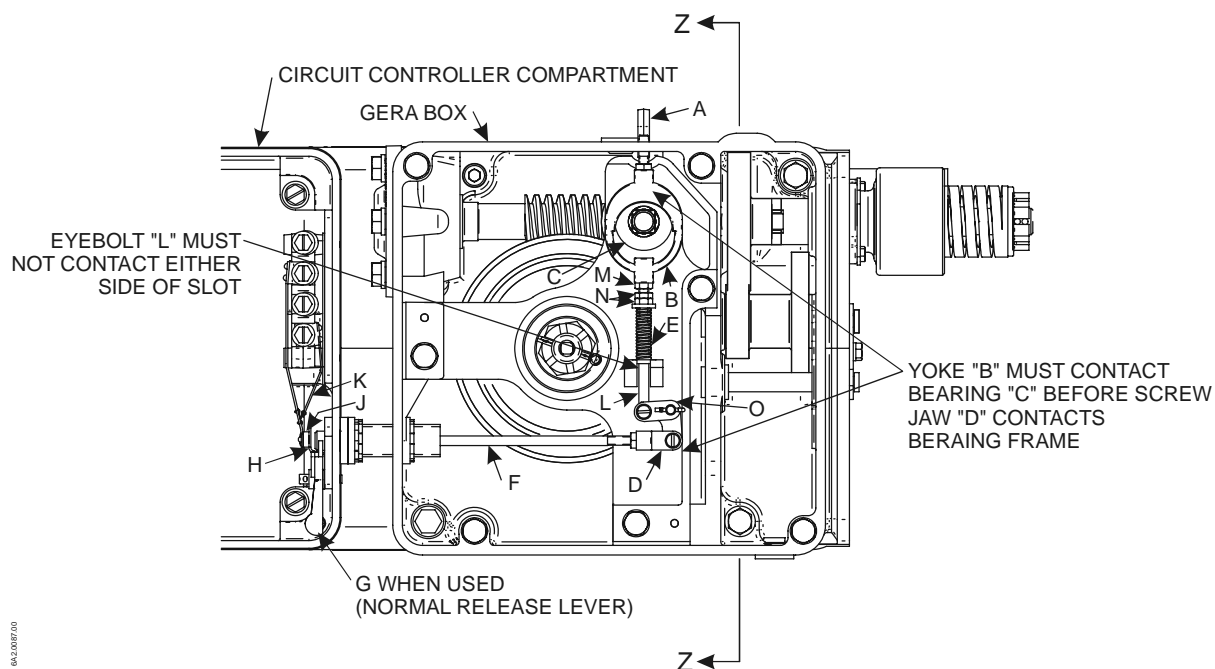
- a. Yoke "B" stops against the bearing "C" as shown in section "Z-Z" in Figure 5-5.
 1. If there is a gap between yoke "B" and bearing "C", inspect eyebolt "L" at slot in bearing "C" (noted in top view of Figure 5-5).
 2. If eyebolt "L" rest against side of slot closest to switch machine motor, loosen nut "M" and remove screw through eyebolt.
 3. Unscrew eyebolt one half revolution.
 4. Install screw through eyebolt from the top down and inspect eyebolt at slot.
 5. If the yoke "B" rests against the bearing "C", tighten the nut "M".
 6. If the eyebolt still rests against the side of the slot, repeat process of unscrewing eyebolt one revolution.



Item Number	Description
A	Push Rod
B	Yoke
C	Bearing
D	Screw Jaw
E	Spring
F	Push Rod
G	Latch

Item Number	Description
H	Bracket
J	Contact Insulation
K	Contact Spring
L	Eyebolt
M	Nut
N	Nuts
O	Locknut

Figure 5-5. Motor Cutout Contacts and Actuator



Item Number	Description
A	Push Rod
B	Yoke
C	Bearing
D	Screw Jaw
E	Spring
F	Push Rod
G	Latch

Item Number	Description
H	Bracket
J	Contact Insulation
K	Contact Spring
L	Eyebolt
M	Nut
N	Nuts
O	Cotter Pin

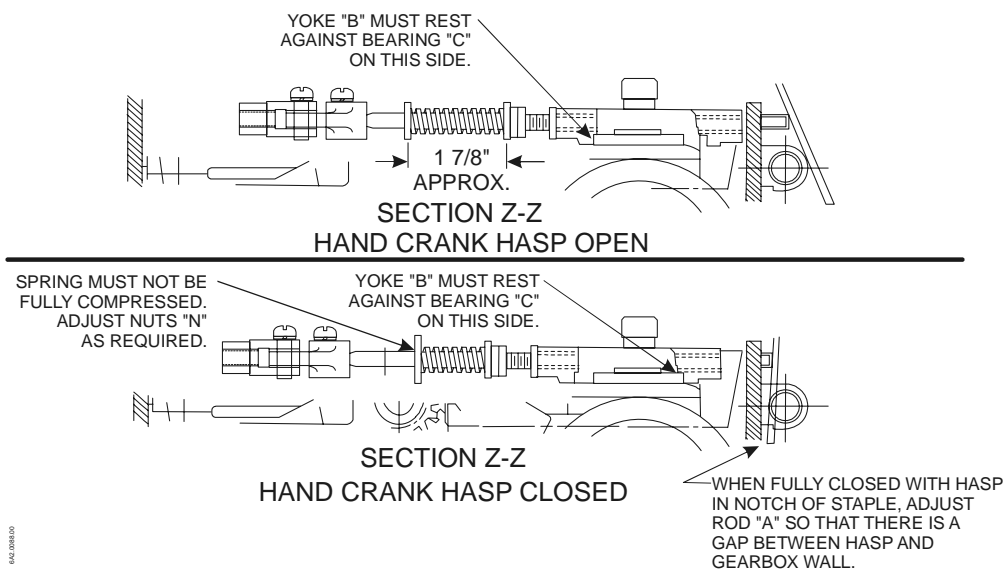


Figure 5-6. Yoke and Bearing Positions

- b. Yoke "B" stops against the bearing "C" as shown in section "Z-Z" in Figure 5-6 with linkage positioned as if the hand crank cover were closed.
 - 1. If there is a gap between yoke "B" and bearing "C", inspect spring on eyebolt "L".
 - 2. If spring is completely compressed solid, loosen nuts "N" until spring is not solid and tighten nuts "N". Rough dimensions are 1 7/8". See Figure 5-7.
 - 3. If there is still a gap between yoke "B" and bearing "C", inspect screw jaw "D" to verify it is not striking the bearing frame (noted in top view of Figure 5-6).
 - 4. If screw jaw "D" strikes the bearing frame, loosen nut "M" and remove the screw in eyebolt "L".
 - 5. Tighten eyebolt one half turn, install screw through eyebolt and tighten nut "M".
 - 6. Verify yoke "B" rests against bearing "C" in both hand crank hasp open and closed positions.
 - 7. Re-adjust if necessary.
 - 8. After verifying the above conditions, manually position the yoke "B" in the hand crank hasp closed position by pressing the push rod "A" inward.
 - 9. With latch release lever "G" released, check the gap in Detail "A" of Figure 5-7.
 - 10. If the gap is not within the specified range of 1/16" to 1/8", loosen the jam nut on push rod "F" and remove the bolt through screw jaw "D".
 - 11. To increase the gap, tighten the screw jaw. To decrease the gap, loosen the screw jaw. Adjust as needed and tighten jam nuts.
- c. Secure the gearbox cover and close the hand crank cover hasp. The hasp must engage the notch in the staple on the gearbox wall but should not contact the gearbox wall when the hasp is fully compressed. See Figure 5-6, Section Z-Z.
- d. If the hasp does not engage the notch in the staple, loosen the jam nut on the push rod "A" and tighten the push rod "A" so that the hasp engages the notch with a maximum gap of 1/32 between the hasp and staple notch.
- e. Tighten the jam nut.

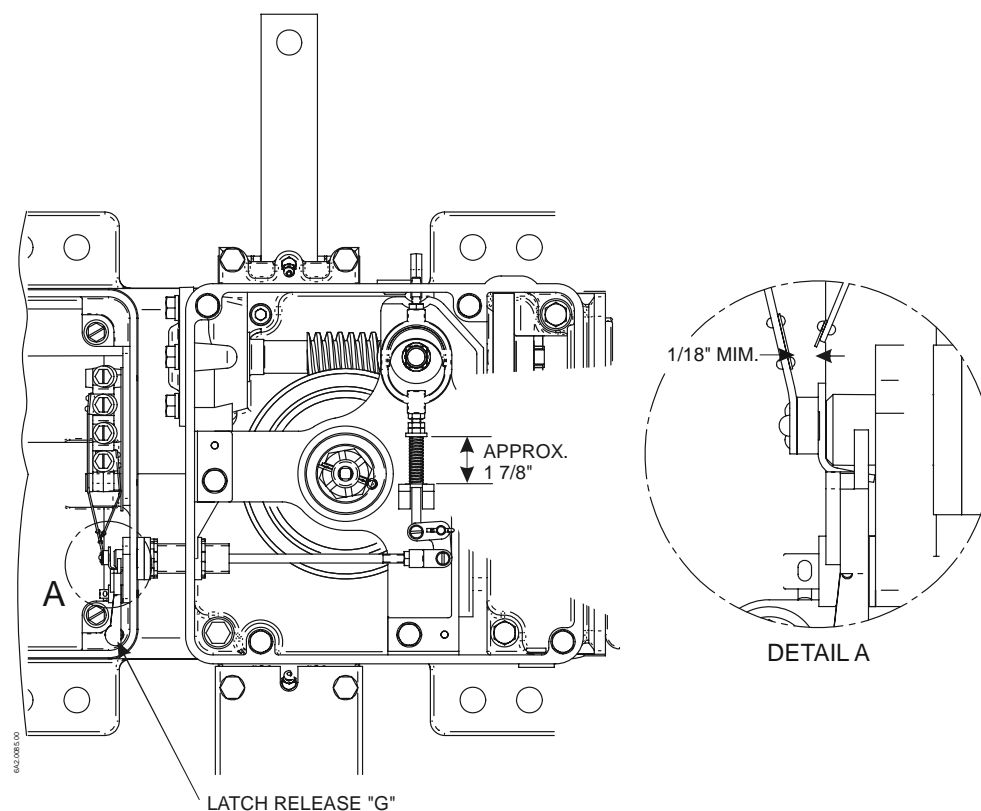


Figure 5-7. Machine in Hand Operation, Covers Open

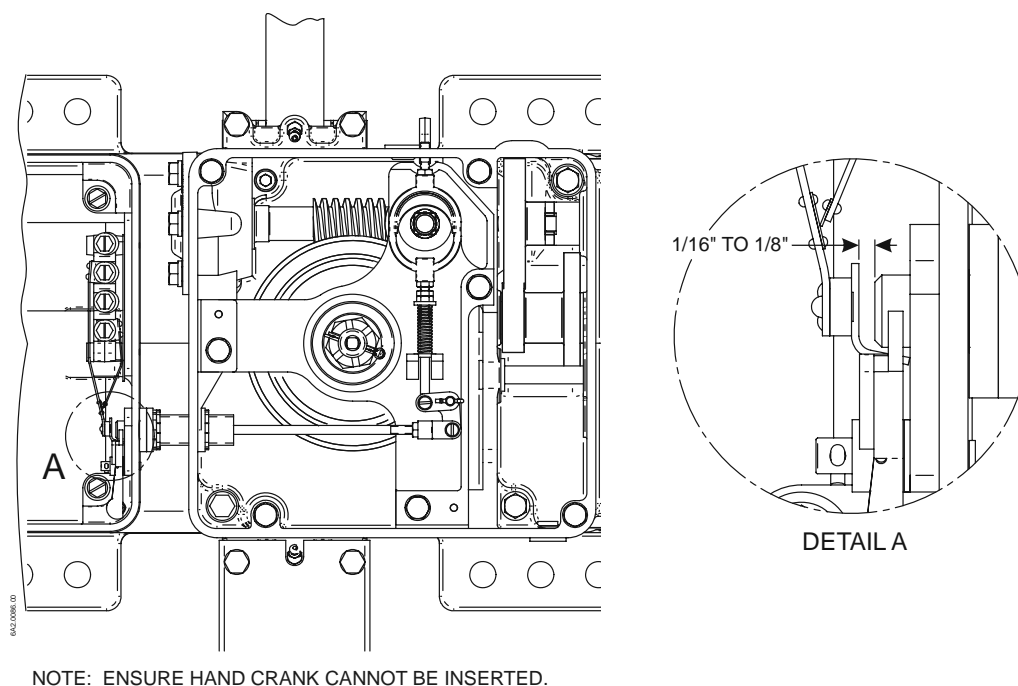


Figure 5-8. Machine in Motor Operation, Covers Closed

IMPORTANT INSPECTION REQUIRMENTS

- a. With the gearbox cover installed and the crank cover open, verify that the motor cutout contacts are dependably open with the crank installed.
- b. Precise measurements are not possible due to all of the manufacturing tolerances. This procedure is a guideline for adjustment
- c. Ensure that there is enough contact pressure to prevent failures due to vibrations created by train movement.

5.7.2.3. M-23A and M-23B Switch Machine Motor Cutout Contacts

Motor cutout contact for the Styles M-23A and M-23B should open when the selector lever is lifted 6" out of MOTOR position, measured at the hand-grip, and be open 1/8" min. To 3/16" max. when the selector lever is in the HAND position. When the selector lever is in MOTOR position, the end of the push rod should be 1/16" clear of the contact operating bar and the contacts should be closed with 1-1/2 lb. Mm. To 2 lb. Max. pressure.

Adjustment of the closed pressure, when necessary, is made by careful use of a spring bender. The linkage which affects the operation should be maintained in adjustment as follows: With selector lever in MOTOR position, the rocker arm (Figure 5-9) should be screwed up or down, as necessary, to just touch the machined cam surface on the selector yoke. Then the adjusting rod should be turned so that its eccentric head holds the end of the push rod 1/16" clear of the contact operating bar.

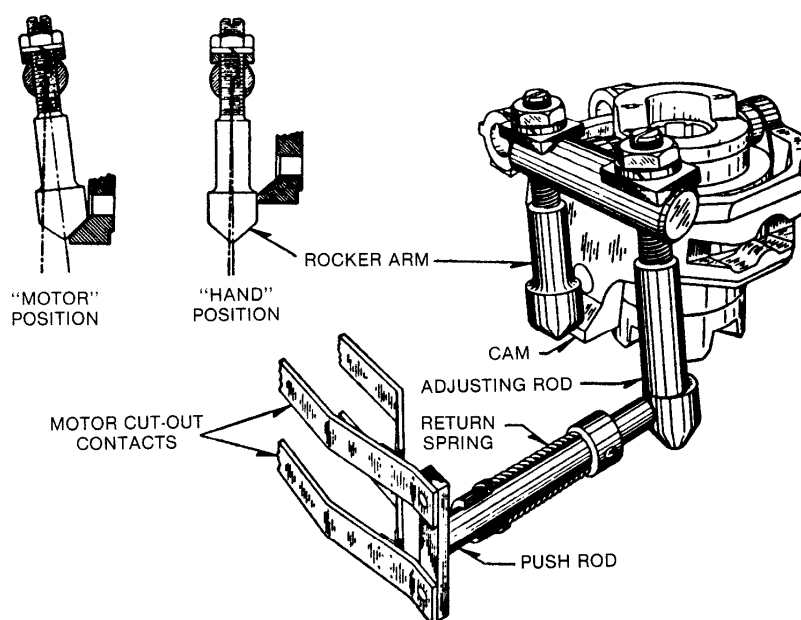


Figure 5-9. M-23A and M-23B Machines Motor Cutout Contact Assembly

5.7.3. Selector Clutch Adjustment

Selector clutch adjustment should be checked occasionally. When the selector lever is in MOTOR position and the selector clutch teeth are in full engagement with the teeth on top of the worm gear so the motor drives the crank, the top rollers on the operating yoke should be just clear of the upper spring cup. This relation can be varied by adjusting the eccentric bushings G1 (Figure 3-12).

Referring to Figure 3-12 and Figure 3-14, note that the selector clutch yoke has one end supported on and driven by the finger on the selector lever shaft, and its other end pivots on eccentric bushings C1 (Figure 3-12) held fixed by through bolt G. When this bolt is loosened, however, the eccentric bushings may be rotated to raise or lower the center line for the pivot holes in the yoke arms, thus affecting the elevation of the yoke rollers. The eccentric bushings have hexagonal heads for application of an adjusting wrench.

On each eccentric bushing, one flat is stenciled "N" which will be on top when the eccentric is in its mean position. The adjacent flat on one side of the "N" is stenciled "+", and when the eccentric bushings are turned to bring the "+" mark up, this will lift the yoke and its rollers. The flat on other side of the "N" is stenciled "-". The two eccentric bushings should be kept turned a like degree "+" or "-" to avoid twisting the yoke. Then tighten pivot bolt to hold adjustment.

When necessary to adjust the eccentric bushings, check that top rollers are free from bearing on the upper spring cup while the selector clutch is fully down, and in addition, check that the rollers are not too high. To do this, operate the selector lever to MOTOR position when the worm gear is not in position to receive the selector clutch, so that the teeth of “clutch for motor operation,” Figure 3-14, ride on top of the corresponding teeth of the worm gear. In doing this, insert 1/8” length of a #14 soft copper wire between the opposed teeth.

The eccentric bushings should be adjusted the same degree “+” or “-” so that (with their bolt tight) when the selector lever is thrown to horizontal position for MOTOR operation, the force between the opposed teeth will crush the wire to not more than 1/32” thickness. Also check that upper rollers are free to turn when selector clutch is fully engaged with the worm gear.



6. CONFIGURATION GUIDE AND PARTS LIST

Table 6-1 lists the available configuration options for the switch machines covered by this manual. Refer to Table 6-2 (M-3), Table 6-3 (M-23A), and Table 6-4 (M-23B) for the actual configuration options that apply to specific switch machines.

Table 6-1. M-3, M-23A, and M-23B Configuration Guide

Reference	Description
A	15W, 230V heater (N285999) for circuit controller compartment
B	15W, 230V heater (N344344) for motor compartment
C	15W, 115V heater (N253225) for circuit controller compartment
D	15W, 115V Heater (N294241) for motor compartment
E	15W, 115/230V heater (N438201) for circuit controller compartment
F (M-3)	15W, 115/230V heater (N294241 & N296578-001) for motor compartment
F (M-23A) F (M-23B)	15W, 115/230V heater (N296577 & N296578-001) for motor
G	15W, 24V heater (N438179) for circuit controller compartment
H	15W, 24V heater (N438178) for motor compartment
J	Lock rod openings closed
K	Provided without main terminal board
L	Uses harness N320067 (flag type terminals)
M	Uses harness N320069 (flag type terminals)
N	Uses circuit controller without point detector latch
O	Clutch set at 14 amps
P (M-3)	Clutch set at 10 amps
P (M-23B)	New switch machines standardized (after Feb. 1, 2004) to reflect three-wire control
Q	Assembled without latch for retaining machine in the off-power position when hand crank cover is open
R (M3)	Aluminum paint
R (M23A)	Ventilators for circuit controller compartment
S (M3)	LH switch machine set up for RH indication or RH switch machine set up for LH indication
S (M23A)	Telephone jack in circuit controller compartment
T (M-3)	15W – 115V heater (N296580-004) for motor compartment
T (M-23A)	With heater thermostat in motor compartment
U (M3)	With telephone jack in circuit controller compartment
V (M3)	For LH switch machine set up for RH indication, machine is stenciled "LH Far Pt Cl." For RH switch machine set up for LH indication, machine is stenciled "RH Far Pt. Cl."
V (M23A)	Heater On/Off switch in motor compartment
W (M3)	1-1/4" threaded conduit outlet
W (M23A)	Short circuiting strip (shunt bar) (M175725) installed
X (M3)	Uses crank case cover (N146290-002); pipe plug (J032902) not required
Y (M-3)	Circuit controller arranged for manual reset of indication contacts
Y (M23A)	Circuit controller without self-restoring latch-out block

Table 6-2. M-3 Switch Machine Assemblies

Part Number		Configuration Ref.	Motor	Gear Ratio	Speed	Control Wiring
Right Hand	Left Hand					
N451160-0301	N451160-0302	C, L	20 VDC	528:1	26 sec.	5 Wire
N451160-0303	N451160-0304	C, M	110 VDC	189:1	4.5 sec.	5 Wire
N451160-0305	N451160-0306	C, D	110 VDC	189:1	4.5 sec.	5 Wire
N451160-0307	N451160-0308	C, D	110 VDC	189:1	4.5 sec.	3 Wire
N451160-0310	N451160-0309	E, F	110 VDC	189:1	4.5 sec.	5 Wire
N451160-0312	N451160-0311	C, D, J	110 VDC	189:1	4.5 sec.	3 Wire
N451160-0313	N451160-0314	X	110 VDC	189:1	4.5 sec.	3 Wire
N451160-0315	N451160-0316	C, D, Q	110 VDC	189:1	4.5 sec.	3 Wire
N451160-0317	N451160-0318	— —	110 VDC	189:1	4.5 sec.	3 Wire
N451160-0319	N451160-0320	C, D	110 VDC	360:1	8 sec.	3 Wire
N451160-0323	N451160-0322	C, D, J, W	110 VDC	189:1	4.5 sec.	3 Wire
N451160-0325	N451160-0324	C, D, J	110 VDC	189:1	4.5 sec.	3 Wire
N451160-0327	N451160-0326	C, D, P, S	110 VDC	360:1	8 sec.	3 Wire
N451160-0329	N451160-0328	C, D, J, R	110 VDC	189:1	4.5 sec.	3 Wire
N451160-0331	N451160-0330	ALSTOM/GRS Replacement Machines (2-Wire Control) – Refer to Section 7				
N451160-0333	N451160-0332	C, D, J, P	110 VDC	360:1	8 sec.	3 Wire
N451160-0335	N451160-0334	C, D, J, P	110 VDC	360:1	8 sec.	3 Wire
N451160-0337	N451160-0336	C, D, J, P, S	110 VDC	360:1	8 sec.	3 Wire
N451160-0339	N451160-0338	ALSTOM/GRS Replacement Machines (2-Wire Control) – Refer to Section 7				
N451160-0341	N451160-0340	C, D, S, V	110 VDC	189:1	4.5 sec.	3 Wire
N451160-0343	N451160-0342	C, D, U	110 VDC	189:1	4.5 sec.	3 Wire
N451160-0345	N451160-0344	C, D, S, U, V	110 VDC	189:1	4.5 sec.	3 Wire
N451160-0351	N451160-0350	C, D, J, V	110 VDC	189:1	4.5 sec.	3 Wire
N451160-4002	N451160-4001	C, D, J	110 VDC	189:1	4.5 sec.	3 Wire
N451160-4004	N451160-4003	C, D, P, S, V	110 VDC	360:1	8 sec.	3 Wire
N451160-4006	N451160-4005	C, D, J	110 VDC	189:1	4.5 sec.	3 Wire

Table 6-3. M-23A Switch Machine Assemblies

Part Number		Configuration Ref	Motor	Gear Ratio	Speed	Control Wiring
Right Hand	Left Hand					
N451160-0502	N451160-0501	--	20 VDC	360:1	15 sec.	5 Wire
N451160-0503	N451160-0506	--	20 VDC	528:1	26 sec	5 Wire
N451160-0504	N451160-0505	K, O	20 VDC	528:1	26 sec	3 Wire
N451160-0507	N451160-0508	--	20 VDC	360:1	15 sec.	5 Wire
--	N451160-0509	C, D	20 VDC	360:1	15 sec.	5 Wire
N451160-0510	N451160-0511	C, D	110 VDC	189:1	4.5 sec.	5 Wire
N451160-0512	N451160-0513	N	20 VDC	528:1	26 sec.	5 Wire
N451160-0514	--		110 VDC	189:1	4.5 sec.	5 Wire
N451160-0515	N451160-0516	A, B	20 VDC	528:1	26 sec.	5 Wire
N451160-0518	N451160-0517	--	20 VDC	528:1	26 sec.	5 Wire
N451160-0520	N451160-0519	R	110 VDC	189:1	4.5 sec.	5 Wire
N451160-0521	N451160-0522	C, D, R	20 VDC	528:1	26 sec.	5 Wire
N451160-0523	N451160-0524	C, D, S, T	110 VDC	189:1	4.5 sec.	3 Wire
N451160-0525	N451160-0526	G, H, S	20 VDC	360:1	15 sec.	5 Wire
N451160-0527	N451160-0528	C, D, V	110 VDC	189:1	4.5 sec.	5 Wire
N451160-0529	N451160-0530	C, D, S, T	110 VDC	189:1	4.5 sec.	3 Wire
N451160-0531	N451160-0532	G, H, S	20 VDC	360:1	15 sec.	3 Wire
N451160-0533	N451160-0534	N	20 VDC	528:1.	26 sec.	5 Wire
N451160-0535	N451160-0536	O, R	110 VDC	189:1	4.5 sec.	3 Wire
N451160-0537	N451160-0538	N, W	20 VDC	528:1	26 sec.	3 Wire
N451160-0540	N451160-0539	G, H	110 VDC	189:1	4.5 sec.	3 Wire
N451160-0541	N451160-0542	G, H	110 VDC	189:1	4.5 sec.	3 Wire
--	N451160-0543	--	110 VDC	189:1	4.5 sec.	5 Wire
N451160-0545	N451160-0544	N, W	110 VDC	189:1	4.5 sec.	3 Wire
N451160-0547	N451160-0546	--	20 VDC	360:1	15 sec.	5 Wire
N451160-0549	N451160-0548	G, H	20 VDC	528:1	26 sec.	3 Wire
N451160-0551	N451160-0550	X	20 VDC	360:1	15 sec.	3 Wire
N451160-1201	N451160-1202	C, D, J	110 VDC	189:1	4.5 sec.	3 Wire
--	N451160-1203	--	110 VDC	189:1	4.5 sec.	3 Wire
N451160-1204	N451160-1205	C, D	110 VDC	189:1	4.5 sec.	3 Wire
N451160-1206	N451160-1207	C, D	20 VDC	360:1	15 sec.	3 Wire
--	N451160-1208	--	110 VDC	189:1	4.5 sec.	5 Wire
N451160-1210	N451160-1209	N, W	20 VDC	528:1	26 sec.	5 Wire
N451160-1212	N451160-1211	C, D, V	110 VDC	189:1	4.5 sec.	3 Wire
N451160-1213	N451160-1214	E, Q, W	20 VDC	528:1	26 sec.	3 Wire
N451160-1215	N451160-1216	C, D	110 VDC	360:1	8 sec.	3 Wire
N451160-1217	N451160-1218	W, Y	20 VDC	528:1	26 sec.	3 Wire
N451160-1219	N451160-1220	C, D	110 VDC	189:1	4.5 sec.	3 Wire
N451160-1222	N451160-1221	C, D	110 VDC	189:1	4.5 sec.	3 Wire
N451160-1224	N451160-1223	--	20 VDC	528:1	26 sec.	3 Wire
N451160-1226	N451160-1225	--	20 VDC	360:1	8 sec.	3 Wire

Part Number		Configuration Ref	Motor	Gear Ratio	Speed	Control Wiring
Right Hand	Left Hand					
N416001-01	N41600102	S, T, W, X	20 VDC	528:1	26 sec.	3 Wire
N416001-04	N41600103	K, N	20 VDC	528:1	26 sec.	3 Wire

Table 6-4. M-23B Switch Machine Assemblies

Part Number		Configuration Ref	Motor	Gear Ratio	Speed	Control Wiring
Right Hand	Left Hand					
N451160-0601	N451160-0602	E, F	20 VDC	360:1	15 sec.	5 Wire
N451160-0604	N451160-0603	--	20 VDC	528:1	26 sec.	5 Wire
N451160-0605	N451160-0606	--	20 VDC	360:1	15 sec.	5 Wire
N451160-0608	N451160-0607	C, D	20 VDC	528:1	26 sec.	5 Wire
N451160-0610	N451160-0609	--	110 VDC	189:1	4.5 sec.	5 Wire
N451160-0611	N451160-0612	C, D	110 VDC	189:1	4.5 sec.	5 Wire
N451160-0613	N451160-0616	C, M	110 VDC	189:1	4.5 sec.	5 Wire
N451160-0615	N451160-0614	G, H	20 VDC	528:1	26 sec.	5 Wire
--	N451160-0617	C, D	110 VDC	189:1	4.5 sec.	5 Wire
--	N451160-0618	C, D	20 VDC	360:1	15 sec.	5 Wire
N451160-0620	N451160-0619	G, H	110 VDC	189:1	4.5 sec.	5 Wire
N451160-0621	N451160-0622	G, H	20 VDC	360:1	15 sec.	5 Wire
N451160-0623	N451160-0624	N	20 VDC	528:1	26 sec.	5 Wire
N451160-0626	N451160-0625	--	20 VDC	528:1	26 sec.	5 Wire
N451160-0627	N451161-0628	C, D	110 VDC	189:1	4.5 sec.	3 Wire
N451160-0630	N451160-0629	G, H	20 VDC	528:1	26 sec.	5 Wire
N451160-0632	N451160-0631	G, H	110 VDC	189:1	4.5 sec.	3 Wire
N451160-0633	N451160-0634	C, D	20 VDC	528:1	26 sec.	3 Wire
N451160-0636	N451160-0635	C, D	110 VDC	189:1	4.5 sec.	3 Wire
N451160-0638	N451160-0637	E, F	110 VDC	189:1	4.5 sec.	5 Wire
N451160-0639	N451160-0640	C, D	20 VDC	360:1	15 sec.	3 Wire
N451160-0642	N451160-0641	E, F	20 VDC	528:1	26 sec.	3 Wire
N451160-0644	N451160-0643	E, F	20 VDC	528:1	26 sec.	5 Wire
N451160-0646	N451160-0645	E, F	20 VDC	528:1	26 sec.	3 Wire
N451160-0648	N451160-0647	K, O, R	20 VDC	528:1	26 sec.	3 Wire
N451160-0650	N451160-0649	C, D, K, N, O, R	110 VDC	189:1	4.5 sec.	5 Wire
N451160-0652	N451160-0651	G, H	20 VDC	360:1	15 sec.	3 Wire
N451160-0654	N451160-0653	C, D	110 VDC	360:1	8 sec.	3 Wire
N451160-0656	N451160-0655	E, F	110 VDC	189:1	4.5 sec.	3 Wire
N451160-0658	N451160-0657	E, F	110 VDC	189:1	4.5 sec.	3 Wire
N416002-01	N416002-02	R, S, T, W	20 VDC	528:1	26 sec.	3 Wire
N416002-03	N416002-04	R, S, T, W	20 VDC	360:1	15 sec.	3 Wire

6.1. M-3 Switch Machine (Single Switch) Parts List

Table 6-5 contains the parts list for the switch machines listed in Table 6-2 (M-3). Figure 6-1 shows a location diagram for the listed parts.

Table 6-5. M-3 Switch Machine (Single Switch) Parts List

Item	Description	Part Number
1	Not Used	--
2	Base Complete	
	Suffixes 0301 – 0304; 0307 – 0310; 0313 – 0318; 0340 – 0341	N291056-002
	Suffixes 0305 – 0306; 0311 – 0312; 0319 – 0320; 0322 – 0323; 0326 – 0329; 4001 – 4004	N294752-001
	Suffixes 0324 – 0325; 0332 – 0337; 4005 – 4006	N451160-1601
	Suffixes 0342 – 0345	N291056
	Suffixes 0350 – 0351	N451160-1602
3	Gearbox Complete	
	Suffixes 0301 – 0302	N287486
	Suffixes 0303 – 0318; 0322 – 0325; 0328 – 0329; 0340 – 0345; 0350 – 0351; 4005 – 4006	N287485
	Suffixes 0319 – 0320	N287484
4	DC Motor Complete	
	Suffixes 0301 – 0302	N451161-1703
	Suffixes 0303 – 0320; 0322 – 0329; 0332 – 0337; 0340 – 0345; 0350 – 0351	N451161-1701
	Suffixes 4001 – 4006	N422008-01
5	Circuit Controller Complete	
	Suffixes 0301 – 0310; 0313 – 0320; 0322 – 0323; 0328 – 0329; 0340 – 0345	N285638
	Suffixes 0311 – 0312; 0326 – 0327; 4001 – 4004	N285638-003
	Suffixes 0324 – 0325; 0332 – 0337; 0350 – 0351; 4005 – 4006	N451817-0501
	Suffixes 0352 – 0353	N451817-0503
6	Screw	J507372
7	Name Plate	J063117
8	Screw, No. 6 x 1/4" Round Head (Plated)	J052607
9	Plate	M146595
10	Not Used	--
11	Not Used	--
12	Screw, 1/2-13 x 1/2" Round Head	J507366
13	Guide Roller	M108315
14	Guide Roller	M074737
15	Locking Bar	N178100
16	Slide Bar (Includes Stud Ref. 103 and Rollers Refs. 104 – 105)	N146444
17	Operating Roller	N061066
18	Operating Bar	M146441

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Item	Description	Part Number
19	Operating Bar Lug	M146443
	Operating Bar Lug, MI (for part numbers N451160- 0514, 0543, 0546, and 0547 only)	M146443001
20	Wearing Bracket	M189024
21	Key	M146782
22	Conduit	J034421
23	Conduit Outlet	N238223
24	Terminal Board (Complete)	N184425
24a	Terminal Board Only	J077952
25	Screw, 3/8-16 x 8" Hex. Rd.	J507369
26	Terminal Board Support	M172662
27	Motor Cutout Push Rod	N180861
28	Strap	M162242
29	Motor Cutout Contact Assembly	N226029
30	Bolt 7/8-9 x 3" Hex. Rd.	J460113
30A	Nut	J048136
30B	Washer	J047773
30C	Cotter Pin	J048636
31	Pipe Nipple	M146723
32	Felt Washer	M147398
33	Washer	M147409
34	Lock Nut	J048415
35	Slide Bar Cover	M074911
36	Circuit Controller Cover (Includes Gasket Ref. 111)	N146698
37	Operating Bar Cover	M148141
38	Operating Bar Cover	M159272
39	Crank Case Cover	M146290
40	Motor Cover (Includes Gasket Ref. 112)	M289299
41	Clip	J700934
42	Washer, No. 10 Flat Steel	J475077
43	Washer, No. 10 Lock Steel	J047733
44	Screw, 1/2-13 x 3/4" Hex	J050086
45	Washer, 1/2" Steel Plated	J047503
46	Screw, 1/2-13 x 1-1/2" Hex	J050092
47	Screw, 1/2-13 x 2" Hex Rd.	J050098
48	Washer	M286594
49	Latch	M186209
50	Spring	M181001
51	Spring Stud	M181032
52	Lock Rod Cover	N269671
53	Locking Screw Complete	N242122
54	Lock Rod Cover	M165752
55	Plate	M165751
56	Spring	J068431

Item	Description	Part Number
57	Point Detector Bar Cover	N296126
58	Point Detector Bar Cover	N296125
59	Lock Nut	M223351
60	Bushing	M296122
61	Lock Washer	J047821
62	Lubricating Fitting, 1/8" P.T. Straight	J039137
65	Collar	M074741
66	Nut	M074742
67	Crank	M071158
68	Worm Gear	M074805
69	Washer	M067454
70	Cotter Pin 1/8 x 3/4"	J048618
71	Gearbox Cover	N152633
71a	Gearbox Gasket	J047286-001
72	Motor Cutout Trigger (Complete)	N146670
73	Push Rod	N146675
74	Jam Nut, 5/16"-18 Steel	J048007
75	Standard Harness for Low Voltage Machines (Not Shown)	N281548
75a	Standard Harness for High Voltage Machines (Not Shown)	N281550
76	Wire Clamp (For Harness) (Not Shown)	J703005
77	Cover Plate	M296066
78	Screw, 1/4-20 x 3/4" Fl. Rd. Steel	J052025
79	Screw	M302256
81	Screw, 1/2-13 x 1" Steel	J050088
82	Screw, 1/2-13 x 1-1/4" Hex	J050090
84	Cotter pin	J048636
85	Pipe Plug	J032901
86	Lubricating Fitting, 1/8" P.T. 671/20	J039142
87	Screw, 5/16-18 x 1-3/4" Steel	J050045
88	Screw, 10-32 x 1/2" Fl. Rd. Steel	J052091
89	Pipe Plug	J032902
90	Long Closed Lock Rod Cover (To be used with lock rods having adjustment on field side similar to A.A.R. drawing 1587.)	N242441
91	Cover Plate	M397927-001
92	Not Used	Not Applicable
93	Stud	M074735
94	Stud	M074736
95	Lock Rod Support	M074738
96	Hinge Lug	N285692
97	Adjustable Hasp	N272961
98	Eccentric Stud	M285680
99	Stud	M147534
100	Hasp	N301050
101	Pin	M209199

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Item	Description	Part Number
102	Rivet	M049475
103	Stud for Ref. 16	M076018
104	Roller for Ref. 16	M076019
105	Roller for Ref. 16	M076020
106	Binding Post only	M115706
107	Nut	J480301
108	Washer	J047818
109	Nut	J480300
111	Gasket, 5'2" long	A067035
112	Gasket (Orders should specify length desired.)	M320440
113	Yoke	M146671
114	Rod	M146674
115	Crank	M146673
116	Screw Jaw	M146677
117	Spring	M074790
118	Washer	M065762
119	Screw	J052202
120	Screw, 10-32 x 9/16" Steel	J522151
121	Harness Clamp	J700589
122	Hand Crank	M146694
124	Washer, Lock	J047521
125	Washer, 1/2" Steel	J047769
126	Washer, 3/8" Steel Lock	J047768
127	Nut, 3/8"-16 UNC.	J048010
129	Washer, 5/16" Plated. Steel Lock	J047526
130	Washer	M002423
132	Screw, 5/16 x 1/2" Hex Rd.	J050034
133	Washer, 5/16" Steel Lock Ex.	J047767
134	Screw, 1/2 x 1-1/2" Socket Head	J050236
135	Washer, 5/16" Steel Plated	J047642
Heater for Circuit Controller Compartment (Not Shown)		
--	15W, 115V	N253225
	15W, 230V	N285999
	15W, 115/230V	N438201
	15W, 24V	N438179
	Heater for Motor Compartment (Not Shown)	
--	15W, 230V	N344344
	15W, 115V	N294241
	15W, 115/230V	N296577 & N296578-0001*
	15W. 24V	N438178

* Both part numbers are required to order the 15W, 115/230V heater.

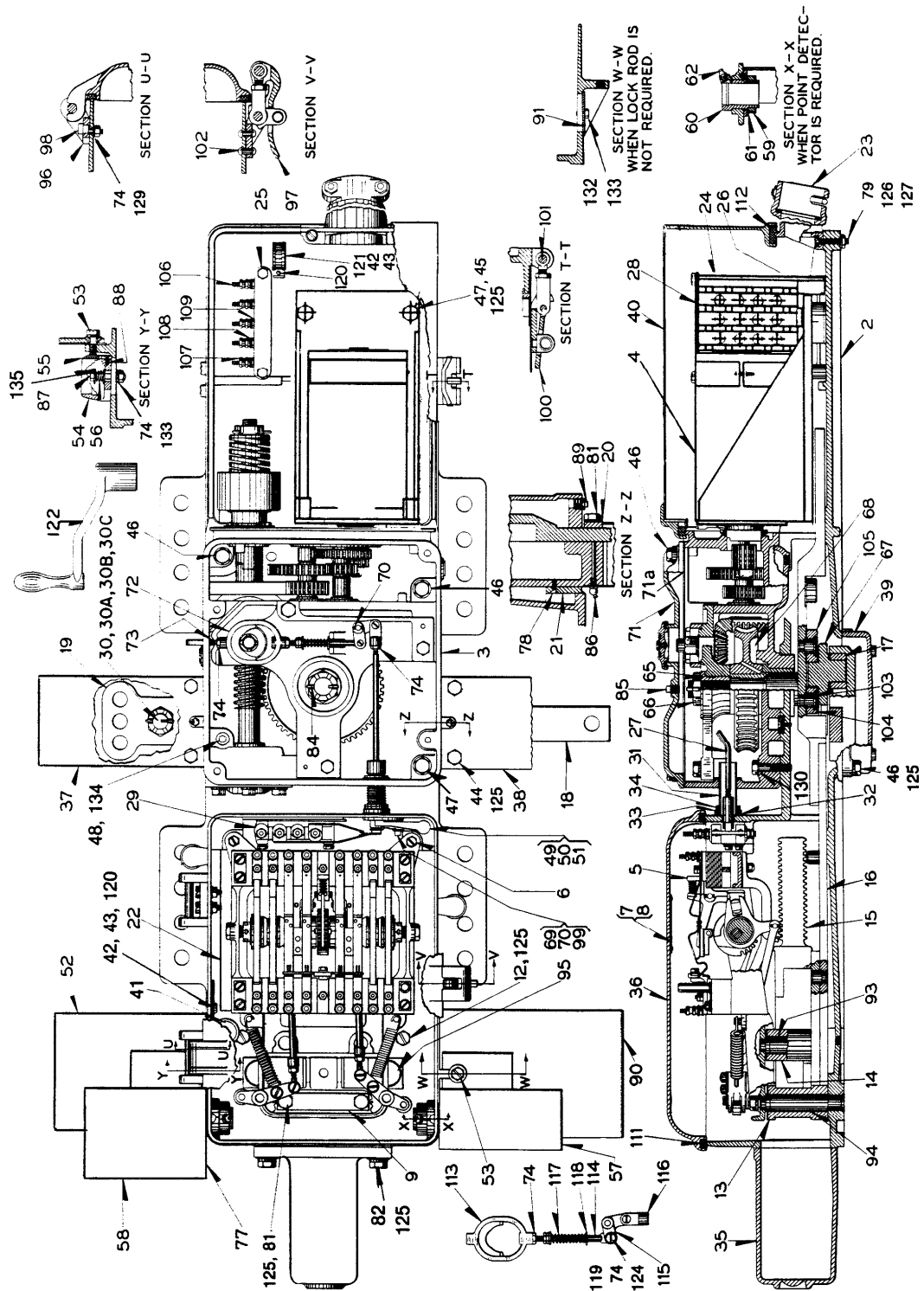


Figure 6-1. M-3 Switch Machine (Single Switch) Parts Location

6.2. M-23A and M-23B Switch Machine (Single Switch) Parts List

Table 6-6 contains the parts list for the switch machines listed in Table 6-3 (M-23A) and Table 6-4 (M-23B). Figure 6-2 shows a location diagram for the listed parts.

Table 6-6. M-23A and M-23B Switch Machine (Single Switch) Parts List

Item	Description	Part Number
1	Not Used	--
2	Base Complete (N451160 Machine Unless Noted Otherwise)	
	Suffixes -0503, 0506 – 0513, 0515 – 0516, 0527 – 0528, 0533 – 0534, 0603 – 0606, 0609 – 0610, 0613, 0616, 0618, 0621 – 0624, 0633 – 0634, 0641 – 0646, 0657 – 0658	N291057
	N416001 Machine Suffixes -01 – 02	
	N416002 Machine Suffixes -01 – 04	
	Suffixes -0523 – 0526, 0529 – 0532	N432466
	Suffixes -0607 – 0608, 0611 – 0612, 0614 – 0615, 0617, 0619 – 0620, 0631 – 0632, 0635 – 0636, 0651 – 0656	N433297
	Suffixes -0501 – 0502, 0504 – 0505, 0514, 0517 – 0518, 0521 – 0522, 0537 – 0538, 0543 – 0547, 0601 – 0602, 0625 – 0628, 0637 – 0640, 0647 – 0648, 1201 – 1203, 1206 – 1208, 1213 – 1216, 1223 – 1226	N293975
	N416002 Machine Suffixes -03 – 04	
3	Suffixes -0519 – 0522, 0535 – 0536	N291057-001
	M-23A Gearbox Complete (N451160 Machine Unless Noted Otherwise)	
	Suffixes -0501, 0508, 0509, 0526, 0532	N287072
	Suffixes -0502, 0507, 0525, 0531, 0546, 0550	N287072-0001
	Suffixes -0503, 0504, 0512, 0515, 0518, 0521, 0533, 0537, 0549, 1210, 1213, 1217, 1224	N287074-0001
	N416001 Machine Suffixes -01, 04	
	Suffixes -0505, 0506, 0513, 0516, 0517, 0522, 0534, 0538, 0548, 1209, 1214, 1218, 1223	N287074
	N416001 Machine Suffixes -02, 03	
	Suffixes 0510, 0514, 0520, 0523, 0527, 0529, 0535, 0540, 0541, 0545, 1204, 1212, 1219, 1222	N287073-0001
	Suffixes -0511, 0519, 0524, 0528, 0530, 0536, 0539, 0542, 0543, 0544, 1201 – 1203, 1205, 1208, 1211, 1220 – 1221	N287073
	M-23B Gearbox Complete (N451160 Machine Unless Noted Otherwise)	
	Suffixes -0601, 0605, 0621	N287075-0001
	N416002 Machine Suffix -03	
	Suffixes -0602, 0606, 0618, 0622, 0640, 0651, 0653	N287075
	N416002 Machine Suffix -04	
	Suffixes -0603, 0607, 0614, 0624, 0625, 0629, 0634, 0641, 0643, 0645, 0647	N287077
	N416002 Machine Suffix -02	
	Suffixes -0604, 0608, 0615, 0623, 0626, 0627, 0630, 0633, 0636,	N287077-0001

Item	Description	Part Number
	0642, 0644, 0646, 0648, 0650, 0656, 0658	
	N416002 Machine Suffix -01	
	Suffixes -0609, 0612, 0616, 0617, 0619, 0628, 0631, 0635, 0637, 0649, 0655, 0656	N287076
	Suffixes -0610, 0611, 0613, 0620, 0639, 0652, 0654	N287076-0001
	N416002 Machine Suffix -02	
4	DC Motor Complete (N451160 Machine Unless Noted Otherwise)	
	Suffixes -0501 – 0502, 0507 – 0509, 0601 – 0602, 0605 – 0606, 0618	N451161-1702
	Suffixes -0503 – 0506, 0512 – 0513, 0515 – 0518, 0603 – 0604, 0607 – 0608, 0614 – 0615	N451161-1703
	Suffixes -0510 – 0511, 0514, 0519 – 0520, 0609 – 0613, 0616 – 0617, 0619 – 0620	N451161-1701
	N416001 Machine Suffixes -01 – 04	N416007-01
	N416002 Machine Suffixes -01 – 04	
5	Circuit Controller (N451160 Machine Unless Noted Otherwise)	
	Suffixes 0512 – 0513; 0533 – 0534; 0537 – 0538; 0544 – 0545; 1209 – 1210; 0623 – 0624; 0649 – 0650	N285638-001
	N416001 Suffixes 03 – 04	
	Suffixes 0504 – 0505, 0514, 0543; 0546 – 0547, 0647 – 0648	N285638-004
	N451160 Suffixes 1217 – 1218	N285638-002
	N451160 Suffixes 1201 – 1202	N285638-003
	All Other Suffixes (N451160, N416001, N416002)	N285638
6	Screw	J507372
7	Name Plate	J063117
8	Screw No. 6 x 1/4"	J052607
9	Plate	M146595
10	Not Used	--
11	Not Used	--
12	Screw, 1/2-13 x 12"	J057366
13	Guide Roller	M108315
14	Guide Roller	M074737
15	Locking Bar	N178100
16	Slide Bar Cam (Includes Studs Ref. 106 and Rollers Ref. 107 and 108)	N146444
17	Operating Roller	M061066
18	Operating Bar	M146441
19	Operating Bar Lug (N451160 Suffixes -0543, -0546, 0547 Only)	M146443-01
	Operating Bar Lug (All Other Suffixes)	M146443
20	Wearing Bracket	M189024
21	Key	M146782
22	Conduit	J034421
23	Conduit Outlet	N238223
24	Terminal Board. (Inc. 1 Ref. 24a, 25 Ref. 101 and 25 Ref. 105)	N184425

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Item	Description	Part Number
24a	Terminal Board Only	M100704
25	Screw, 3/8-16 x 8" Hex Hd.	J507369
26	Terminal Board Support	M172662
27	Motor Cutout Push Rod	N286607
28	Screw, 3/8-16 x 1/2" Hex Hd.	J050049
29	Motor Cutout Contact Assembly	N226028
30	Bolt, 7/8-9 x 3" Hex	J460113
30A	Nut, 7/8" 9 UNC.	J048136
30B	Washer, Steel Lock	J047773
30C	Cotter Pin, 3/16 x 2"	J048636
31	Pipe	M286599
32	Felt Washer	M147398
33	Washer	M147409
34	Lock Nut	J048415
35	Slide Bar Cover	M074911
36	Circuit Controller Cover (Inc. Gasket Ref. 109)	N149924
37	Operating Bar Cover	M148141
38	Operating Bar Cover	M159272
39	Crank Case Cover	M146290
40	Motor Cover (Includes Gaskets Ref. 110)	N289299
41	Clip	J700934
42	Not Used	--
43	Screw, 10-32 x 9/16" Fil. Rd.	J522151
44	Bolt	J050098
45	Bolt	J050092
47	Screw	J050236
47a	Washer	M286594
48	Motor Cutout Push Rod Spring	M286589
49	Lock Rod, Cover	N269671
50	Locking Screw	N242122
51	Lock Rod Cover	M165752
52	Plate	M165751
53	Spring	J068431
54	Point Detector Bar Cover	N296126
55	Point Detector Bar Cover	N296125
56	Lock Nut	M223351
57	Selector Lever	M274597
58	Hand Throw Lever	R435598-001
59	Cap Screw, 1/2-13 x 1-3/4" Knurled Socket Hd.	J050237
60	"Motor" Plate	M287198
61	"Hand" Plate	M287199
62	Screw	J052174
63	Harness for Low Voltage Machines (Not Show)	N281548
63a	Harness for High Voltage Machines (Not Show)	N281550

Item	Description	Part Number
64	Wire Clamp (For Harness) (Not Shown)	J703005
65	Heater, 15W, 115V for Circuit Controller Compartment (Not Shown)	N253225
66	Bushing	M296122
67	Cover Plate	M296066
68	Bolt	J050086
69	Not Used	--
70	Not Used	--
71	Not Used	--
71a	Not Used	--
72	Screw	J052025
73	Screw	M302256
73a	Jam Nut	J048010
74	Bolt	J050088
75	Screw, 1/2-13 x 1-1/4" Hex	J050090
76	Bolt	J050092
77	Screw, 10-32 x 9/16" Fil. Hd.	J522151
78	Steel Ball, 3/4" Diameter	J066012
79	Bushing	M308325
80	Lubricating Fitting, 1/8" P.T., 67-1/2°	J039142
81	Bolt	J050044
82	Screw	J052091
83	Bushing	M399589
84	Pipe Plug	J032902
85	Lock Washer	J047821
86	Lubricating Fitting, 1/8" P.T.	J039137
87	Burndy Cable Clamp HP-24N	J700589
88	Long Closed Lock Rod Cover	N242439
88a	Long Closed Lock Rod Cover (To be used with Lock Rods having adjustment on field side similar to AREMA Drawing 1587)	N242441
89	Bolt	J050048
89a	Lock Washer	J047768
90	Stop Off Screw	M287186
91	Stud	M074735
92	Stud	M074736
93	Lock Rod Support	M074738
94	Hinge Lug	N285692
95	Adjustable Hasp	N272961
96	Eccentric Stud	M285680
97	Hasp	N301050
98	Pin	M209199
99	Rivet	J049475
100	Rivet	J049452
101	Binding Post Only	M115706
102	Nut	M029101

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Item	Description	Part Number
103	Washer	J047818
104	Nut	M029103
105	Tag (Orders should specify marking desired) (Not shown)	M142777
106	Not Used	--
107	Not Used	--
108	Not Used	--
109	Not Used	--
110	Not Used	--
111	Screw, No. 12-28 x 1-1/8" Rd. Hd. S. (Plated) w/Nut Ref. 111a	J052614
111a	Nut	M035216
112	Washer	N218713
113	Cover Plate	M397927-001
114	Ventilator	N070109
115	Nut 5/16"-18 UNC.	J048006
116	Washer, 5/16" Steel Lock Plated	J047526
117	Washer, 3/8" Steel. Lock	J047768
118	Washer, 1/2" Steel. Lock	J407769
119	Nut, 3/8 Hex Jam	J048010
120	Strap	M162242
121	Washer, 5/16" Steel. Plated.	J047642
122	Nut, 5/16"-18 UNC.	J048006
123	Screw, 5/16 x 1/2" Hex Hd.	J050034
124	Washer, 5/16" Steel Lock.	J047767
125	Washer	M002423
126	Washer, #10 Steel Lock Med.	J047733
127	Washer, #10 Fil. Steel	J475077
129	Heater For Circuit Controller (Not Shown) 15W, 115V	N253225
	15W, 230V	N285999
	15W, 115V	N438201
	15W, 24V	N438179
130	Heater For Motor Compartment "Blue" Motor (Not Shown)	
	15W, 230V	N344344
	15W, 115V	N294241
	15W, 24V	N438178
	15W, 115/230V	N296577 & N296578-001*
131	Heater for Motor Compartment "Gray" Motor (Not Shown) 15W, 115/230V	N4515890101

* Both part numbers are required to order the 15W, 115/230V heater

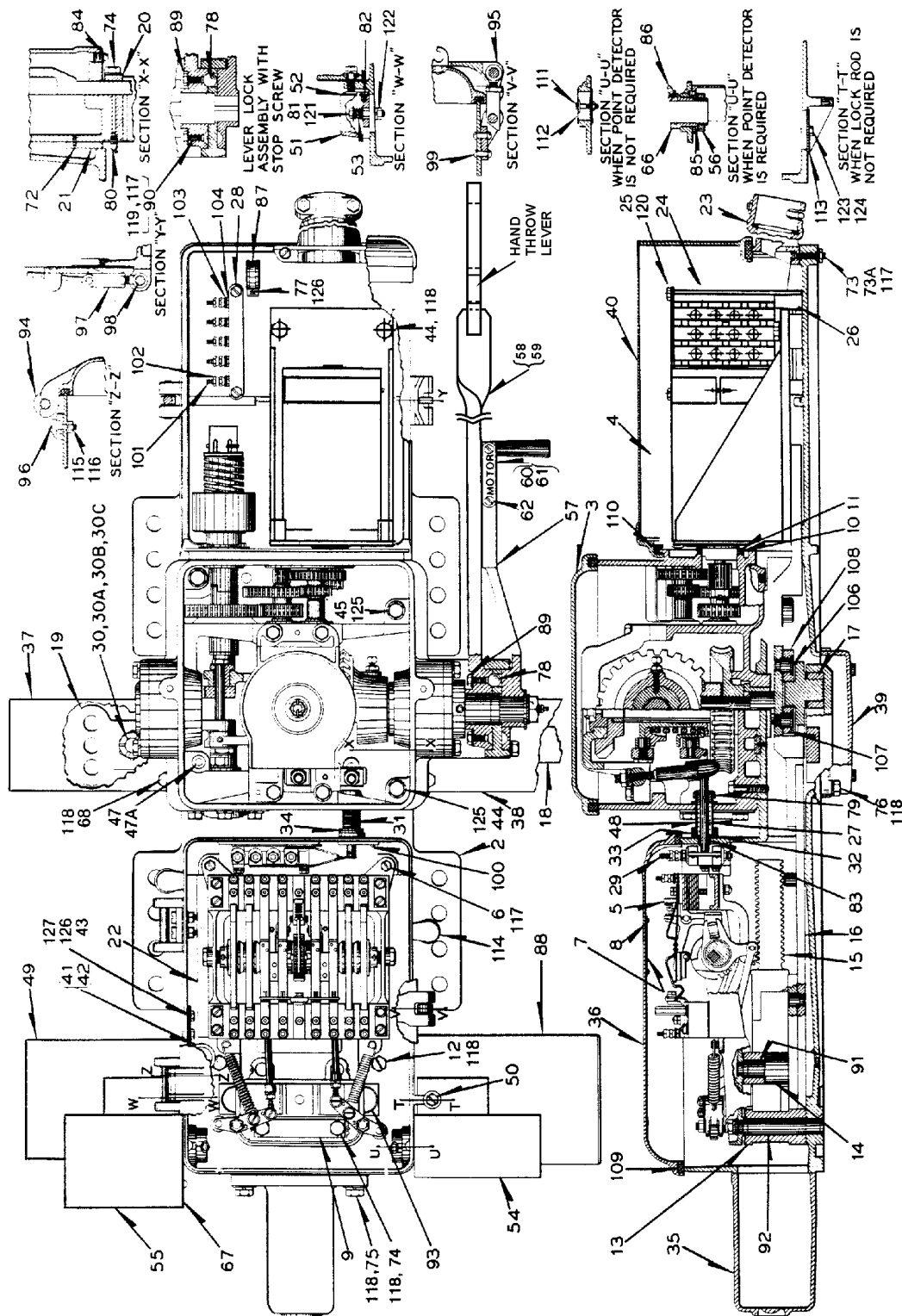


Figure 6-2. M-23A and M-23B Switch Machine (Single Switch)

6.3. M-3 Switch Machine Gear Box Parts List

Table 6-7 contains the parts list for the gear boxes used in the switch machines listed in Table 6-2 (M-3). Figure 6-3 shows a location diagram for the listed parts.

Table 6-7. M-3 Gear Box Parts List

Item	Description	Part Number
	Gear Box Complete	
	189:1 Gear Ratio	N287485
	360:1 Gear Ratio	N287484
	528:1 Gear Ratio	N287486
1	Not Used	--
2	Gear Box (Includes Bushings & Oil Seals Items 44 – 50)	N287085
3	Top Bearing	N146606
4	Worm and Shaft	M286612
5	Clutch Housing	N172752
6	Clutch End Plate	M146575
7	Clutch Plate	M146574
8	Clutch Plate	M146573
9	Clutch Disk	M146650
10	Clutch Spring	M239322
11	Clutch Adjusting Nut	M286615
12	Felt Washer	J047335
12a	Oil Seal	J790026-0003
13	Gasket	M245192
14	Plate	M147400
16	Gasket	M147410
17	Bearing Cap	M274596
18	Clutch Gear Comp. (Includes Bushing Item 51)	N286583
19	Hand Crank Bevel Gear	M286995
20	Hand Crank Bevel Pinion	M146377
21	Shaft	M149700
22	First Reduction Gear (360:1 Gear Ratio)	M286577
22a	First Reduction Gear (528:1 Gear Ratio)	M286579
23	First Reduction Gear (189:1 Gear Ratio)	M286576
24	Second Reduction Gear (360:1 Gear Ratio)	M286578
24a	Second Reduction Gear (528:1 Gear Ratio)	M286580
25	Spacer	M286591
26	Spacer	M286592
27	Shaft End Plate	M286587
28	Dowel	J048925
29	Washer	J079694
30	Gear Train Cover Complete	N287089
31	Shaft	M292426

Item	Description	Part Number
32	Hasp Lug	M165738
33	Oilite Bushing	J079694
34	Bolt, 5/16 x 3/4", Hex Hd	J050036
34a	Lock Washer	J047526
35	Bolt, 1/2-13 x 1 1/4"	J050090
36	Bolt, 1/2-13 x 1 1/2	J050092
36a	Lock Washer	J047783
37	Pipe Plug 1/2" CI CSK	J032904
38	Ball Bearing	J066032
39	Ball Bearing	J066246
40	Lock Washer, Shake Proof	J047810
41	Lock Nut	J048575
42	Key	J048755
43	Retaining Ring	J790076
44	Bushing	J790008
45	Bushing	J790007
46	Bushing	J790004
47	Bushing for Crank (not shown)	M451393-0501
48	Bushing	J790291
49	Bushing	J790290
50	Oil Seal	J790261
51	Bushing	J790328

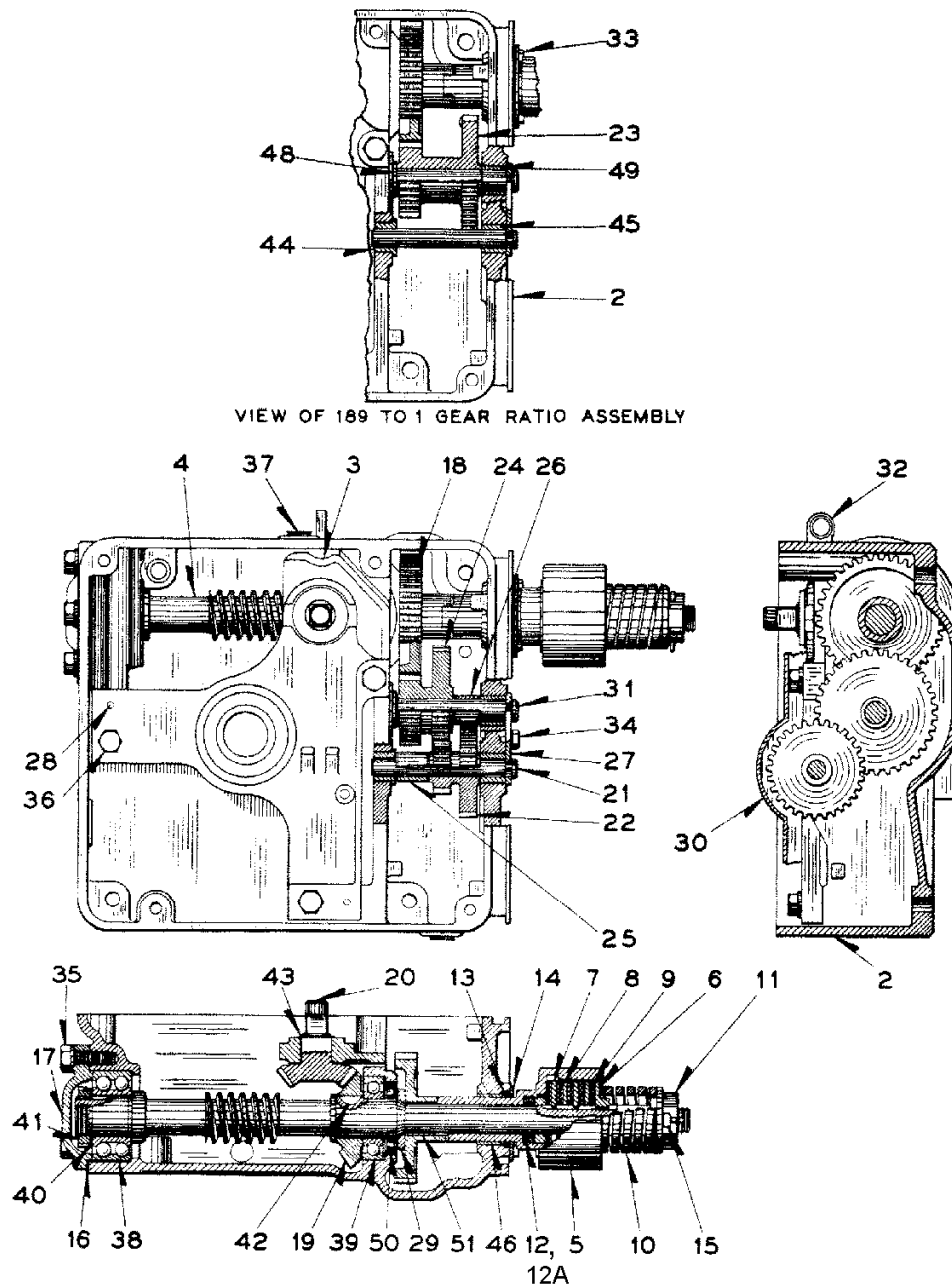


Figure 6-3. M-3 Switch Machine Gear Box Parts Location

6.4. M-23A and M-23B Switch Machine Gear Box Parts List

Table 6-8 contains the parts list for the gear boxes used in the switch machines listed in Table 6-3 (M-23A) and Table 6-4 (M-23B). Figure 6-4 shows a location diagram for the listed parts.

Table 6-8. M-23A and M-23B Gear Box Parts List

Item	Description	Part Number
Ref.	Gear Box Complete (M-23A)	
	189:1 Gear Ratio (Left Hand)	N287073
	189:1 Gear Ratio (Right Hand)	N287073-0001
	360:1 Gear Ratio (Left Hand)	N287072
	360:1 Gear Ratio (Right Hand)	N287072-0001
	528:1 Gear Ratio (Left Hand)	N287074
	528:1 Gear Ratio (Right Hand)	N287074-0001
Ref.	Gear Box Complete (M-23B)	
	189:1 Gear Ratio (Left Hand)	N287076
	189:1 Gear Ratio (Right Hand)	N287076-0001
	360:1 Gear Ratio (Left Hand)	N287075
	360:1 Gear Ratio (Right Hand)	N287075-0001
	528:1 Gear Ratio (Left Hand)	N287077
	528:1 Gear Ratio (Right Hand)	N287077-0001
1	Not Used	--
2	Gearbox (Includes Bushings & Oil Seals)	N286623
3	Top Bearing	M274599
4	Worm Shaft	M286612
5	Friction Clutch Housing	N172752
6	Friction Clutch End Plate	M146575
7	Friction Clutch Plate	M146574
8	Friction Clutch Plate	M146573
9	Friction Clutch Disk	M146650
10	Friction Clutch Spring	M239322
11	Friction Clutch Adjusting Nut	M438402-001
12	Gasket	M245192
13	Felt Washer	J047335
13A	Oil Seal	J7900260003
14	Plate	M147400
16	Gasket	M147410
17	Bearing Cap	M274596
18	Clutch Gear (Includes Bushing Ref. 88)	N286583
19	Spacer	M286593
20	Worm Gear	M286620
21	Hand-Throw Bevel Pinion (M-23A Machines)	M286616
21A	Hand-Throw Bevel Pinion (M-23B Machines)	M286617

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Item	Description	Part Number
22	Hand Throw Bevel Gear	M286611
23*	Main Crank (5-Spline)	M302731
23A	Main Crank (10-Spline)	M286608
24	Hand Throw Lever Shaft	M286618
25	Selector Lever Shaft	M286619
26	Shaft	M149700
27	First Reduction Gear (360:1 Gear Ratio)	M286577
27A	First Reduction Gear (528:1 Gear Ratio)	M286579
28	First Reduction Gear (189:1 Gear Ratio)	M286576
29	Second Reduction Gear (360:1 Gear Ratio)	M286578
29A	Second Reduction Gear (528:1 Gear Ratio)	M286580
30	Spacer	M286591
31	Spacer	M286592
32	Shaft End Plate	M286587
33	Dowel	J048925
34	Bushing	M169502
35	Key	M174967
36	Washer	J475187
36a	Lock Washer	J047783
37	Castle Nut	J048057
38	Cotter Pin	J048613
39	Bushing	M169503
40*	Selector Clutch (5-Spline Main Crank)	N302735
40a*	Selector Clutch (10-Spline Main Crank)	N286672
41	Selector Clutch Yoke	N286622
42	Roller	M217537
43	Roller	M217538
44	Roller Stud	M261981
45	Eccentric Bushing	M261980
46	Bolt, 1/2-13 x 6" Hex Hd.	J050251
46a	Washer	J475187
47	Gear Train Cover	N286603
48	Shaft	M286596
49	Cam Follower Link	M286614
49a	Washer	M286584
50	Cutout Rod Adjuster Link	M286613
51	Washer	M286595
52	Gasket	M286585
53	Yoke Support	M274598
54	Lever Shaft Bearing	M274603
55	Shaft	M292426
56	Lever Support	M274602
57	Gearbox Cover	N288677
58	Bushing Oilite	J079694

Item	Description	Part Number
59	Lubricating Fitting, 1/8" P.T.	J039137
60	Plate Washer, 7/8" Plain S. Plated	J047508
61	Lock Washer, 7/8" Plain S. Plated	J047742
62	Jam Nut, 7/8" Plain S. Plated	J048069
63	Set Screw, 3/8-16 x 1-1/2" Sq. Rd.	J050621
63a	Jam Nut, 3/8-16 Hex Plated	J048010
63b	Lock Washer, 3/8" Plain S. Plated	J475121-0113
64	Cap Screw, 1/2-13 x 4-3/4", Hex. Plated	J050107
64a	Lock Washer, 1/2" Plain S. Plated	J047783
65	Cap Screw, 1/2-13 x 1-1/2" Hex Plated	J050092
65a	Lock Washer, 1/2" Plain S. Plated	J047783
66	Cap Screw, 1/2-13 x 1-3/4" Hex Plated	J050095
66a	Lock Washer, 1/2 Plain S. Plated	J047783
67	Cap Screw, 1/2-13 x 1-1/4" Hex Plated	J050090
67a	Lock Washer, 1/2" Plain S. Plated	J047783
68	Cap Screw, 1/4-20 x 3/4" Hex Plated	J050016
69	Cap Screw, 5/16-18 x 3/4" Hex Plated	J050036
69a	Lock Washer, 5/16" Plain S. Plated	J047526
70	Ball Bearing (Double Row)	J066032
71	Ball Bearing	J066246
72	Lock Washer	J047810
73	Lock Nut	J048575
74	Pipe Plug	J032904
75*	Clutch for 5-Spline Main Crank (Hand Operation)	N302734
75a*	Clutch for 10-Spline Main Crank (Hand Operation)	N286671
76	Clutch for 5-Spline Main Crank (Motor Operation)	M302732
76a	Clutch for 10-Spline Main Crank (Motor Operation)	N286669
77	Upper Clutch Cup	M292411
78	Clutch spring	M253753
79	Lower Clutch Cup	M218627
80	Gasket, 1/2" sq. x 4'-5" long	J067035
81	Bushing	J790008
82	Bushing	J790007
83	Bushing	J790004
84	Bushing	M4513930501
85	Bushing	J790291
86	Bushing	J790290
87	Oil Seal	J790261
88	Bushing	J790328

* Care must be taken when ordering these items as some M-23A and M-23B machines were furnished with 10-spline main cranks and repair parts must be ordered to suit.

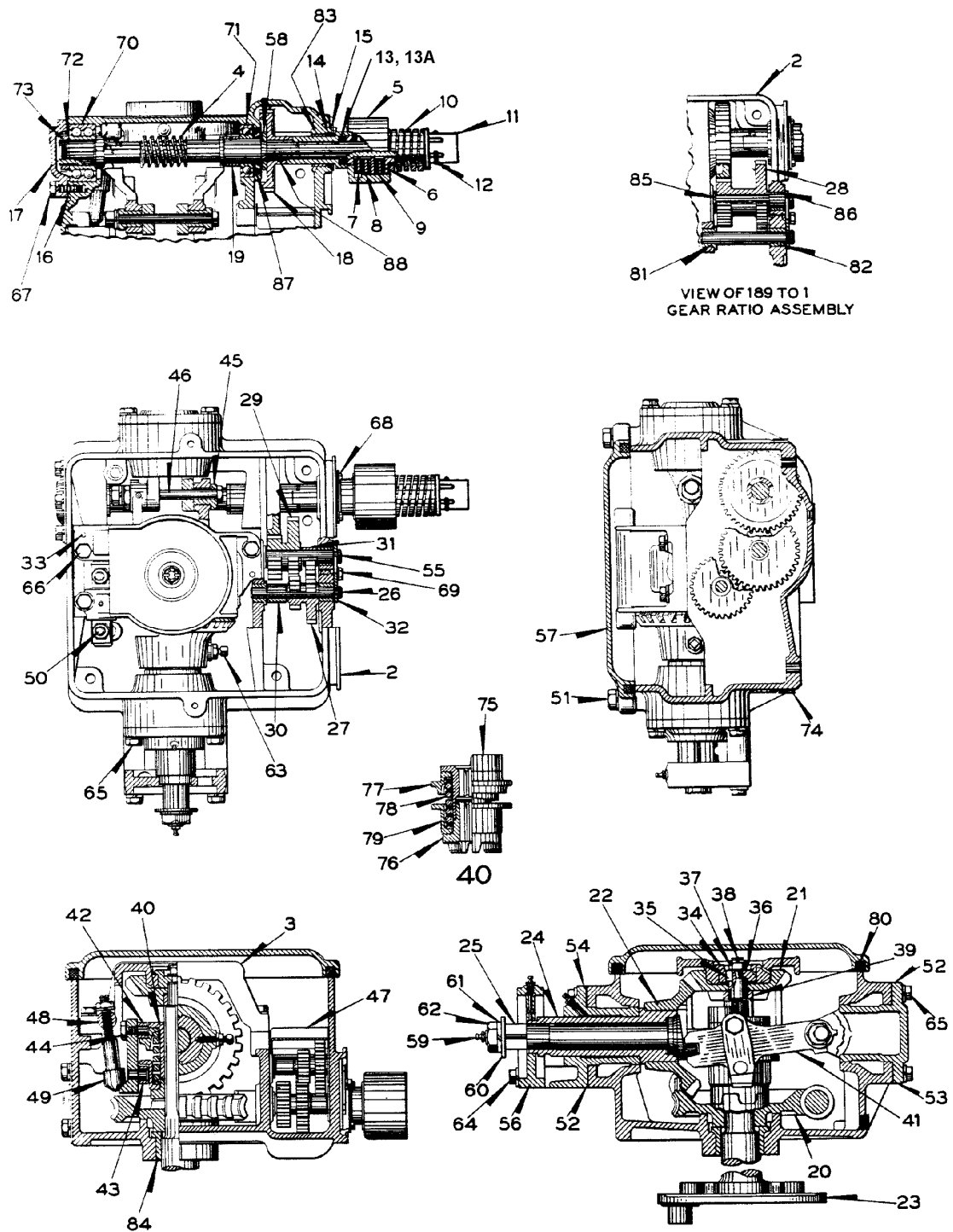


Figure 6-4. M-23A and M-23B Gear Box Parts Location

6.5. M-3, M-23A, and M-23B Indication Circuit Controllers

Table 6-9 contains the parts list for the circuit controllers used in the switch machines listed in Table 6-2 (M-3), Table 6-3 (M-23A), and Table 6-4 (M-23B). Figure 6-5 shows a location diagram for the listed parts.

Table 6-9. M-3, M-23A, and M-23B Indication Circuit Controllers

Item	Description	Part Number
	Circuit Controller with Selective Point Detector	N285638
		N285638002
		N285638-003
		N285638-004
		N451817-0501
		N451817-0503
	Circuit Controller without Point Detector Latch	N285638-001
1	Frame, Complete	N284499
2	Idler Bearing	N338004
	Pinion, 1-9/16" Steel Round	M074796
	Pin, 3/8" Steel Round	M338002
3	Bracket	M284493
4	Yoke, Complete	N284681
	Bushing, 0.3755" ID x 0.564" OD	M284682
	Bushing, Oil Impregnated	M284717
5	L.H. Crank	N284650
	Roller, 7/8" Steel Round	M284423
	Roller, Pin	M284851
6	R.H. Crank	N284649
	Roller, 7/8" Steel Round	M284423
	Roller, Pin	M284851
7	Connecting Rod	N338005
	Lever, Operating Component	N284651
	Rod, Connecting	M282430
	Pin, 1/4" Steel Round	M338003
8	Latch	M284495
9	Eccentric Bushing	N284653
	Bushing, Eccentric	M284652
	Roll Pin, Elastic Stop 1/8 x 1/2"	J048718
10	Coil Spring	M142167
11	Short Circuiting Strip Support	M074427
12	Eye Bolt	M164921
13	Spring, Lever	J068952
14	Terminal Board	J077705
15	Terminal	M146475
16	Terminal Connector	M146476

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Item	Description	Part Number
17	Terminal Connector	N146478
	Terminal Connector	M146477
	Pin, 3/32 x 7/16" Dowel	J703421
18	Insulation	M142173
19	Terminal Post	M138723
20	Nut, 0.437" Brass Hex	M026545
21	Terminal Post	M048854
22	Washer, 17/64 x 9/16" Copper	J047818
23	Nut, #14-24 Hex Brass NP	J480300
24	Spring Indication	N284721
25	Spring	M074783
26	Spring	M138718
27	Spring	M074777
28	Spring	M045269
29	Spring	M172380
30	Short Circuiting Strip	M175725
31	Stud	M152038
32	Plate	M146775
33	Screw, 7/16" Steel Hex Head	M056236
34	Trunnion	M055305
35	Trunnion	M285410
36	Nut, #11 Soft Brass	M050258
37	Washer	M042627
38	Washer	M042585
39	Washer	M048692
40	Contact Segment	M045942
41	Insulating Bushing	J078019
42	Indication Cam	M284494
43	Washer	J475180
44	Cam Spring	J068281
45	Gear (-001 and -003 Controllers)	N284679
46	Main Shaft	M282431
47	Screw, #8-32 x 5/16" SAFSET	J050731
48	Pin, Operating	M285389
49	Washer	J475186
50	Nut, 5/16" - 24Hex	J048005
51	Latch Pin	M284718
52	Screw, 3/8-24 x 1-1/4" Socket Head	M285432
53	Screw, 9/16" Steel Round Head	M236061
54	Shim, #29 Steel Sheet	M134595
55	Contact Spring	M251938
56	Stop Spring	M251939
57	Stop Spring	M251940
58	Spring Seat	M285393

Item	Description	Part Number
59	Screw, 5/16-18 x 5/8" Flat Head	J052362
60	Washer	M339088
61	Wire, Soft Black Iron W-18	A043025
62	Screw, 5/16"-18 Hex Head	M451358-3324
63	Washer, 5/16" Steel Extra Lock	J047767
64	Washer, 1/4" Plate Steel Lock	J047766
65	Washer, 3/8" SST Lock	J475121-0113
66	Cotter Pin, 1/16 x 1/2" SST KKT	J048686
67	Cotter Pin, 3/32 x 1" SST	J048613
68	Cotter Pin, 1/8 x 1/2" SST	J486001
69	Fitting, Hyd. 90 degree Ell. 1/8" NPT	J039150
70	Retaining Ring	J790074
71	Fiber Washer	M056203
72	Nut, #14-24 Hex Brass	J480301
73	Shim (0.016")	M451161-4902
74	Shim (0.026")	M451161-4903
75	Nut, 1/2"-20 Thick Slotted	J048057
76	Washer, 5/16" Plate Steel Lock	J047526
77	Heater, Complete	N253225
78	Screw, 5/16 x 2" SST Fillister Head	J052219
79	Washer, 5/16" SST Plate	J475120-0113
80	Tie Bar, Long	N439065
81	Tie Bar, Short	N439066
82	Gear (N285638-004 Controllers)	N294584

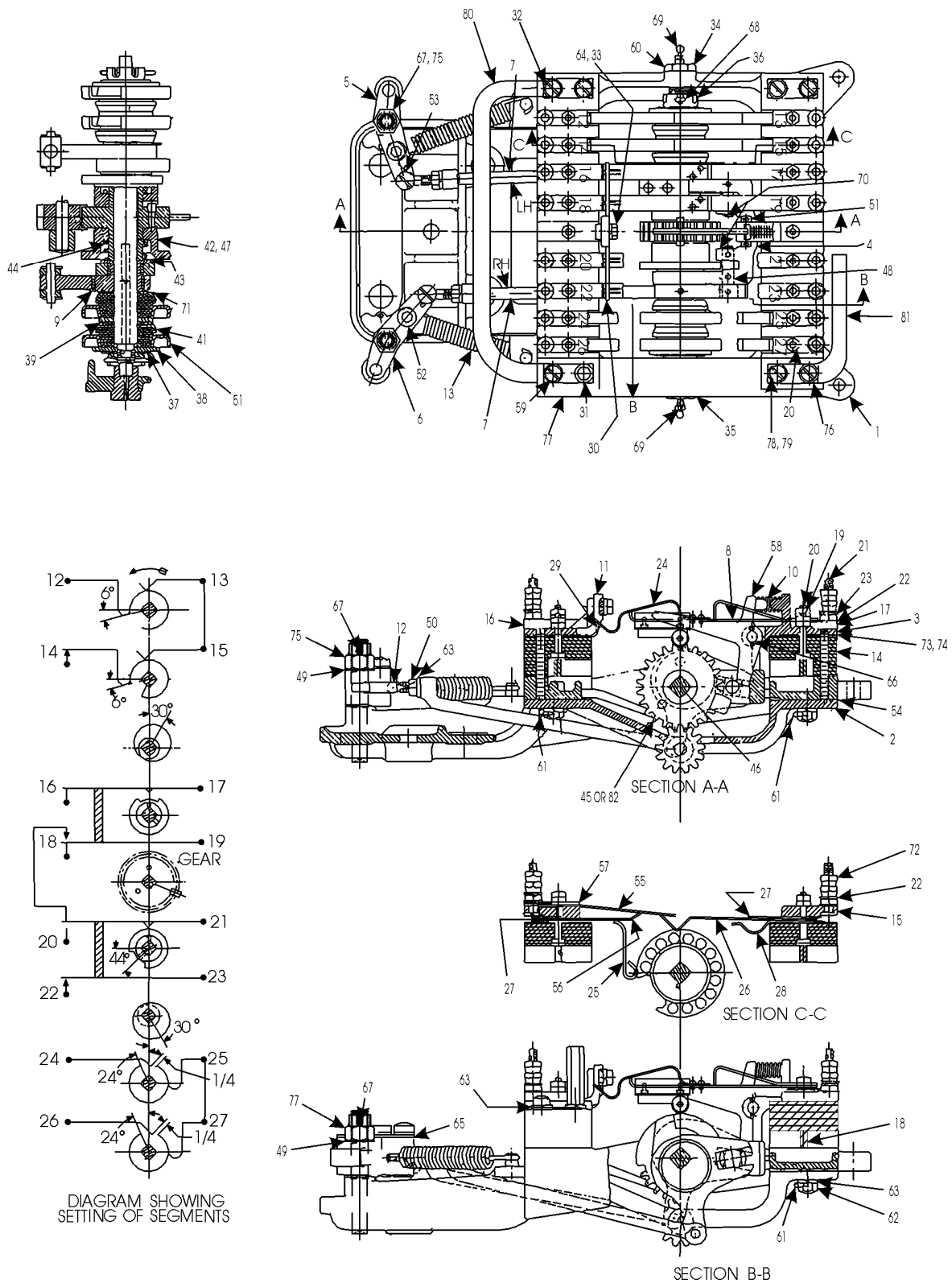


Figure 6-5. Indication Circuit Controller Parts Location

6.6. M-3, M-23A, and M-23B Standard Base (Complete)

Table 6-10 contains the parts list for the base used in the switch machines listed in Table 6-2 (M-3), Table 6-3 (M-23A), and Table 6-4 (M-23B).

Table 6-10. M-3, M-23A, and M-23B Standard Base (Complete)

Machine	Arranged for Special Equipment	Part Number
M-3	Standard	N291056-002
	With Telephone Jack	N291056
	With Machined Mounting Lugs	N294752-001
		N451160-1601
		N451160-1602
		N451160-1603
M-23A, M-23B	Standard	N291057
	With Ventilators in Circuit Controller Compartment	N291057-001
	With Machined Mounting Lugs	N293975
M-23A	With Telephone Jack	N432466
M-23B	With 1-1/32" Holes (Lugs)	N433297

To obtain service parts for machines with non-standard bases, specify the top-level piece number of the machine.

6.7. M-3, M-23A, and M-23B Motor Assemblies

Table 6-11 contains the parts list for the motor assemblies used in the switch machines listed in Table 6-2 (M-3), Table 6-3 (M-23A), and Table 6-4 (M-23B). Figure 6-5 and shows a location diagram for the listed parts.

Table 6-11. M-3, M-23A, and M-23B Motor Assemblies

Item	Description	Part Number
	High Voltage Motor Assembly (110 VDC)	N422008-01
		N451161-1701
	Low Voltage Motor Assembly (20 VDC)	N416007-01
		N422008-02
		N451161-1702
		N451161-1703
5	Motor Frame Adapter (Not Required with J717245-0002 Motor)	M410006-02
10	"Blue" Motor – Electric 110 VDC (189:1 and 360:1 Gear Ratio)	J717216-0301
	"Blue" Motor – Electric 20 VDC (360:1 and 528:1 Gear Ratio)	J717216-0302
	"Blue" Motor – Electric 20 VDC (528:1 Gear Ratio)	J717216-0303
	"Black" Motor – Electric 20 VDC (360:1 and 528:1 Gear Ratio)	J717216-0501
	"Black" Motor – Electric 20 VDC (189:1 and 360:1 Gear Ratio)	J717216-0502
	"Gray" Motor – Electric 20 VDC (360:1 and 528:1 Gear Ratios)	J717245-0002
25	Screw, 3/8-16 x 1" Hex Socket Head (Not Required with J717245-0002 Motor)	J500124-0002

Item	Description	Part Number
30	Gear, 1-1/2" Steel Round	M451161-1601
35	Key, 3/16" Square Steel	M451161-1305
40	Screw, 10-32 x 1/4" Allen Head	J507363
45	Snap Ring, Ext. Retaining	J792852
60	Washer, 17/64 x 9/16" Copper (Not Required with J717216-0301 Motors)	J047818
65	Washer, 5/16" Ext. Cnsk. Lock (Not Required with J717216-0301 Motors)	J475143-0001
70	Washer, 3/8" Ext. Cnsk. Lock (Not Required for J717245-0002 Motor)	J475143-0002

Table 6-12. M-3, M-23A, and M-23B Motor Brushes

Motor Part Number	Brush Kit Part Number	Spring Kit Part Number
J717216-0301	X410000-04	X410000-05
J717216-0302	X410000-06	X410000-07
J717216-0303	X410000-06	X410000-07
J717216-0501	J717245-0009	J717245-0007
J717216-0502	J717245-0009	J717245-0007
J717245-0002	J717245-0009	J717245-0007

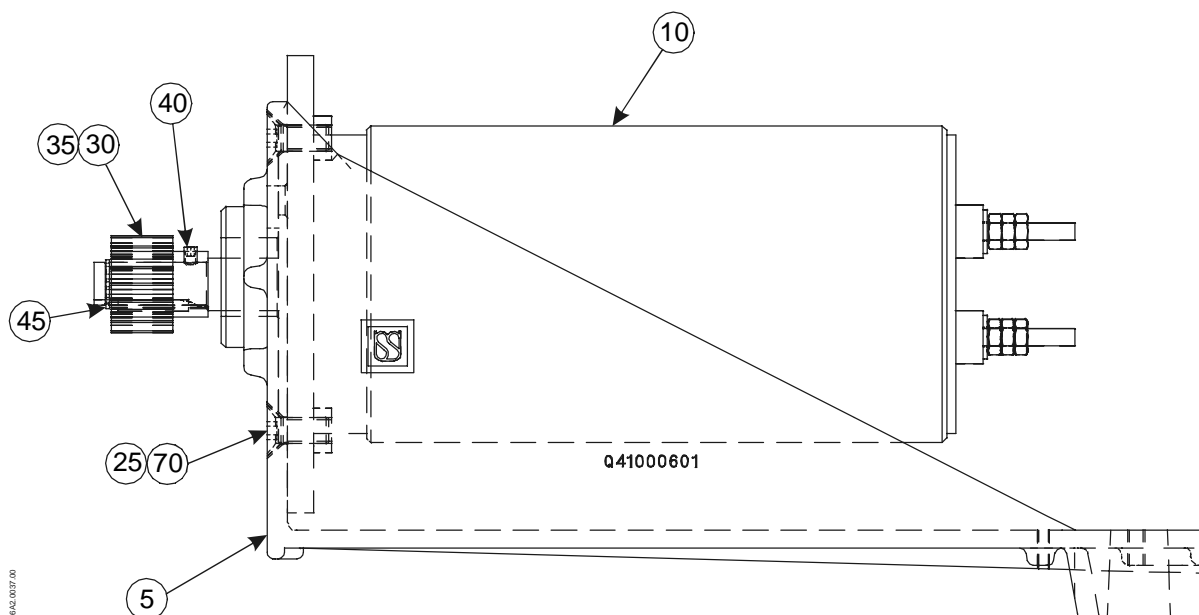


Figure 6-6. M-3, M-23A, and M-23B "Blue" Motor Assembly

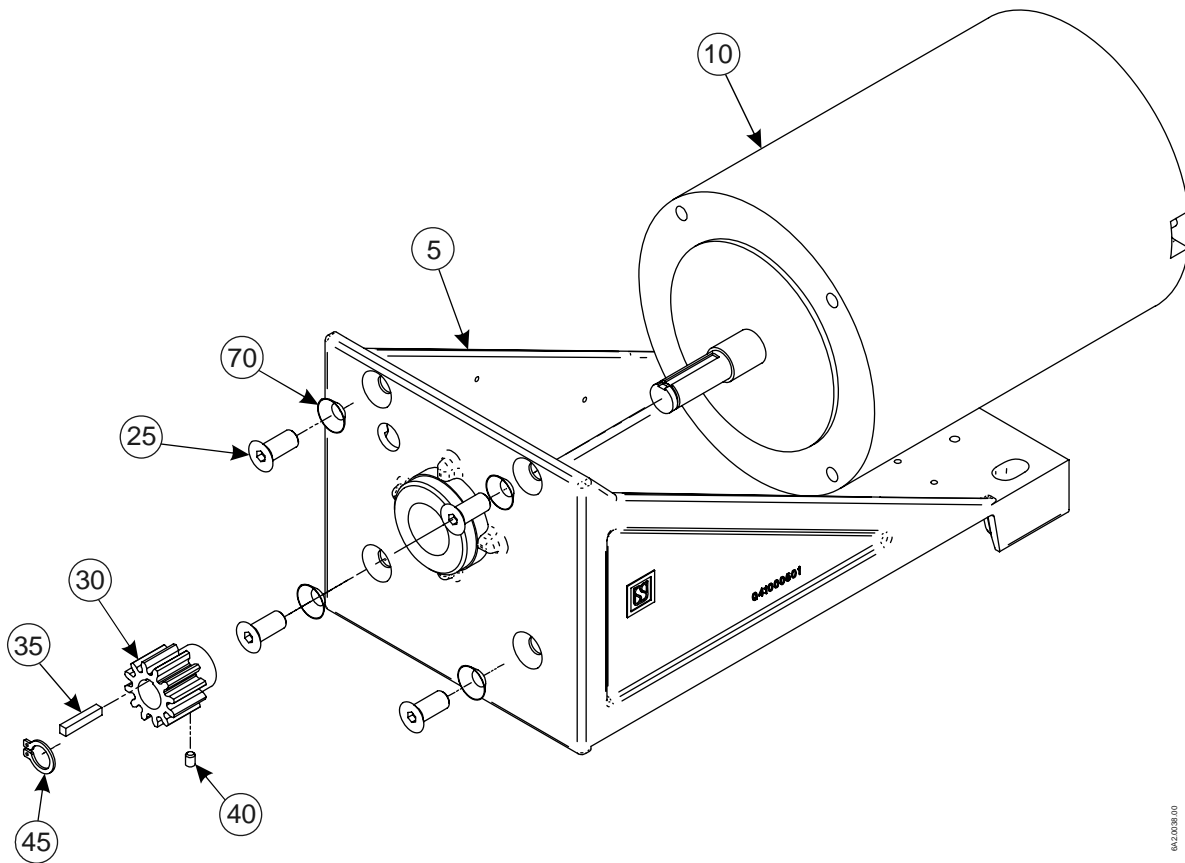


Figure 6-7. M-3, M-23A, and M-23B "Black" Motor Assembly

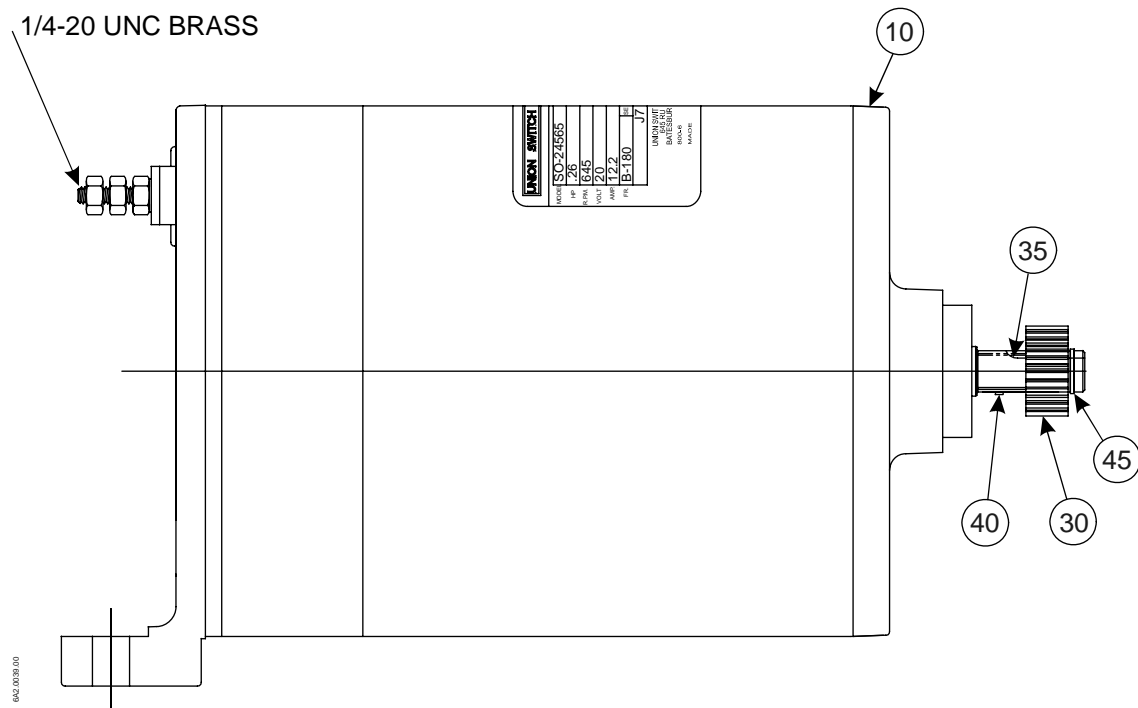


Figure 6-8. M-3, M-23A, and M-23B “Gray” Motor Assembly



7. TWO-WIRE CONTROL FOR ALSTOM/GRS REPLACEMENT MACHINES

7.1. Configuration Guide

Table 7-1 lists the available configurations for the ALSTOM/GRS replacement switch machines. Table 7-2 lists the assemblies for these switch machines.

Table 7-1. ALLSTOM/GRS Replacement Switch Machine Configuration Guide

Reference	Description
C	15W – 115/230V heater (N253225) in circuit controller compartment
S	LH machine set up for RH indication or RH machine set up for LH indication
T	15W – 115V heater (N296580-004) in motor compartment
U	With telephone jack in circuit controller compartment

7.2. Switch Machine Assemblies

Table 7-2. ALLSTOM/GRS Replacement Switch Machine Assemblies

Part No.		Ref.	Motor	Speed	Gear Ratio
Left Hand	Right Hand				
N451160-0330	N451160-0331	C, T, U	110 VDC	4.5 sec.	189:1
N451160-0338	N451160-0339	C, S, T, U	110 VDC	4.5 sec.	189:1

7.3. Switch Machine Parts List

Table 7-3. ALLSTOM/GRS Replacement Switch Machine Parts List

Item Number	Description	Part Number ⁽¹⁾
2	Base with Telephone Jack	N291056
4	DC Motor Complete	N451161-1706
75b	Wiring Harness For Two-Wire Control	N41000401
--	Heater For Motor Compartment (Not Shown)	N296580-004
140	Microphone Jack	M263133
141	Component Shield	R311667
142	Jack Board	M311692
143	Jack Board	M311693
144	Garlock Gasket	J047430
145	Cover Complete	N216833
146	Screw, 8-32 X ¼ Flat Head	J521104
147	Screw, 10-32 X 1 1/8 Fillister Head	J522021
148	Washer, 3/8 Shakeproof Lock	J047672
149	Washer, #10 SST Lock	J475121-0109
150	12 Amp Diode Assembly	N410005-01

Two-Wire Control for ALSTOM/GRS Replacement Machines



Item Number	Description	Part Number ⁽¹⁾
151	12 Amp Diode Assembly	N451005-02
152	Contactorm Assembly ⁽²⁾	N451161-5303
	Contactorm Assembly ^{(2) (3)}	N410011-01
153	Contactorm Wire Harness ⁽⁴⁾	N451161-5902
	Contactorm Wire Harness ⁽⁴⁾	N451161-5904
154	Self Adhesive Tag "N"	J075827-0003
155	Self Adhesive Tag "R"	J075827-0004

⁽¹⁾ Listed part numbers are either alternates or additions to the parts list shown in Table 6-5.

⁽²⁾ Contactor N451161-5303 was no longer available starting October 2005. It was used in all replacement switch machines manufactured prior to that date. Contactor N410011-01 is a direct replacement, but harness N451161-5904 must be used along with it.

⁽³⁾ Contactor N410011-01 was used in all replacement switch machines manufactured beginning October 2005.

⁽⁴⁾ Harness N451161-5904 will work in all replacement switch machines, but is longer than the N451161-5902 harness. To use the -5904 harness in machines manufactured prior to October 2005, adjust the harness routing within the machine to allow for the extra length.

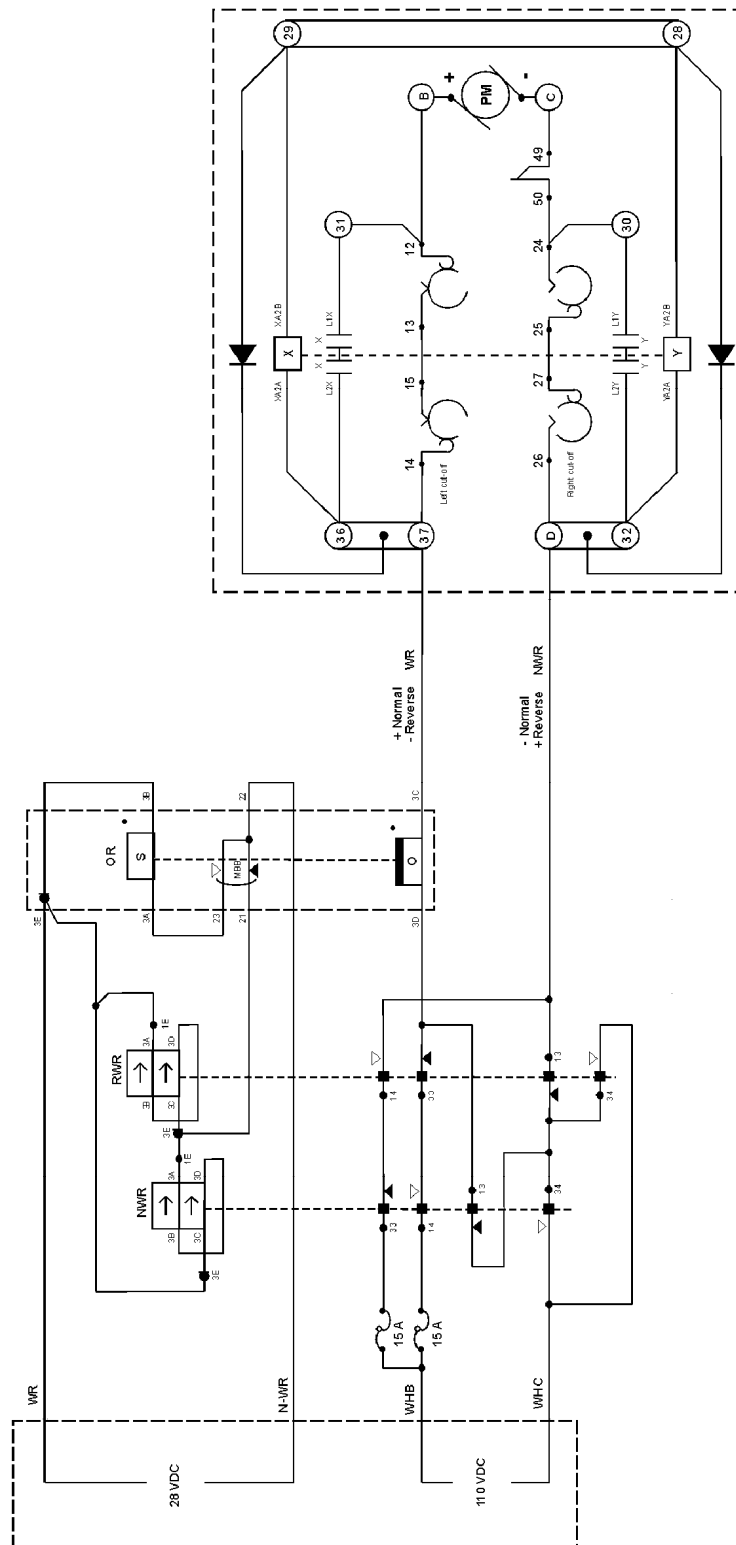


Figure 7-1. Two-Wire Control Circuit (Sheet 1 of 2)

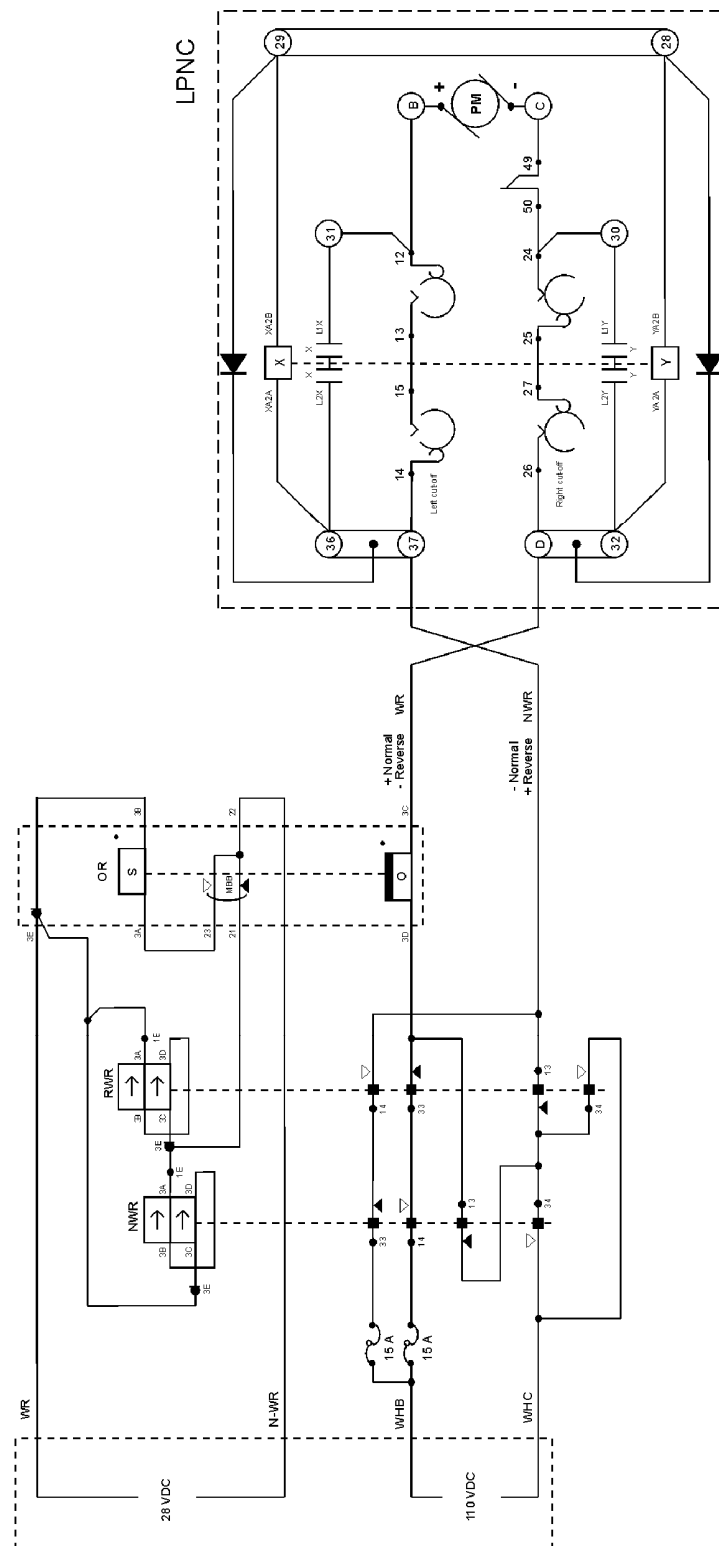


Figure 7-2. Two-Wire Control Circuit (Sheet 2 of 2)

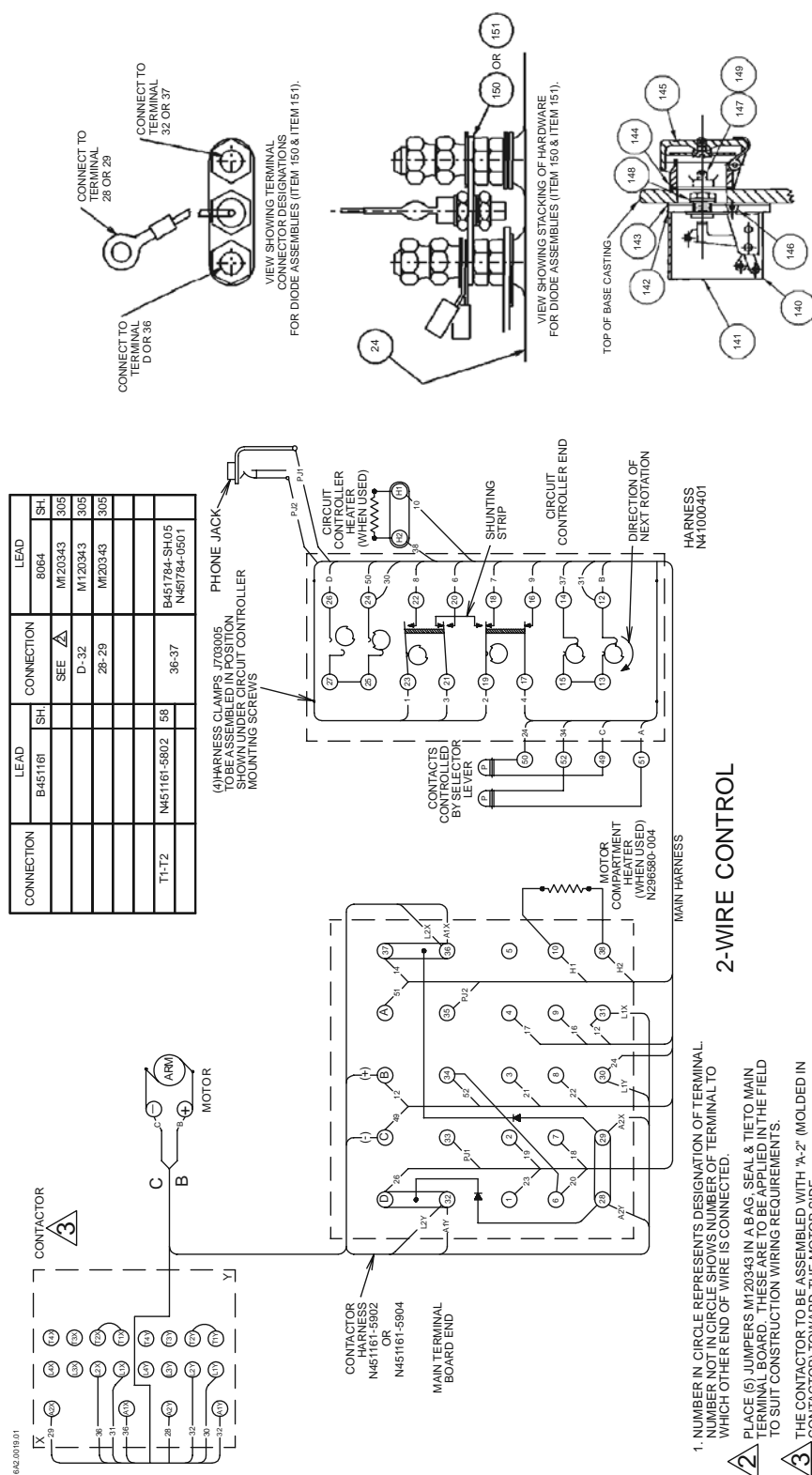


Figure 7-3. Two-Wire Control Schematic

7.4. Contactor Assembly (N451161-5303)

Machines manufactured before October 2005 use contactor N451161-5303. Machines manufactured beginning October 2005 use contactor N410011-01 (see Section 7.5).

Table 7-4. Contactor Assembly (N451161-5303) Parts List

Item	Description	Part No.
1	Screw, 6-32 x 1/4"	J525055
2	Washer, #6 Lock	J047662
3	Screw, 8-32 x 1", RH	J052604
4	Washer, #8 Lock	J047681
5	Nut, 8-32	J048166
6	Screw, 8-32 x 5/8", RH	J052602
7	Shock Mount	J751329
8	Contactor	J709599-0002
9	Top Mount Plate	M451161-5301
10	Bottom Mount Plate	M451161-5302
11	Snub Washer	J475078-0001
12	Jumper	N451614-5802
13	Clip, Burndy HP-8N	J700590
14	Screw, 8-32 x 1-1/4" Round Head	J525111
15	Tag, "X" ("X" relates to "N")	J075827-0001
16	Tag, "Y" ("Y" relates to "R")	J075827-0002

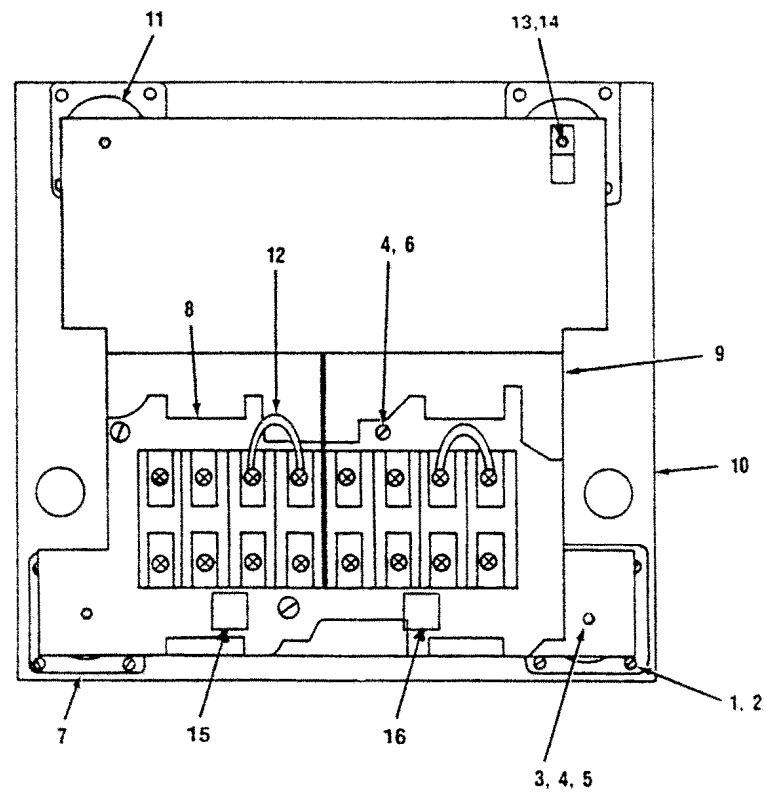


Figure 7-4. Contactor Assembly (N451161-5303) Parts Location

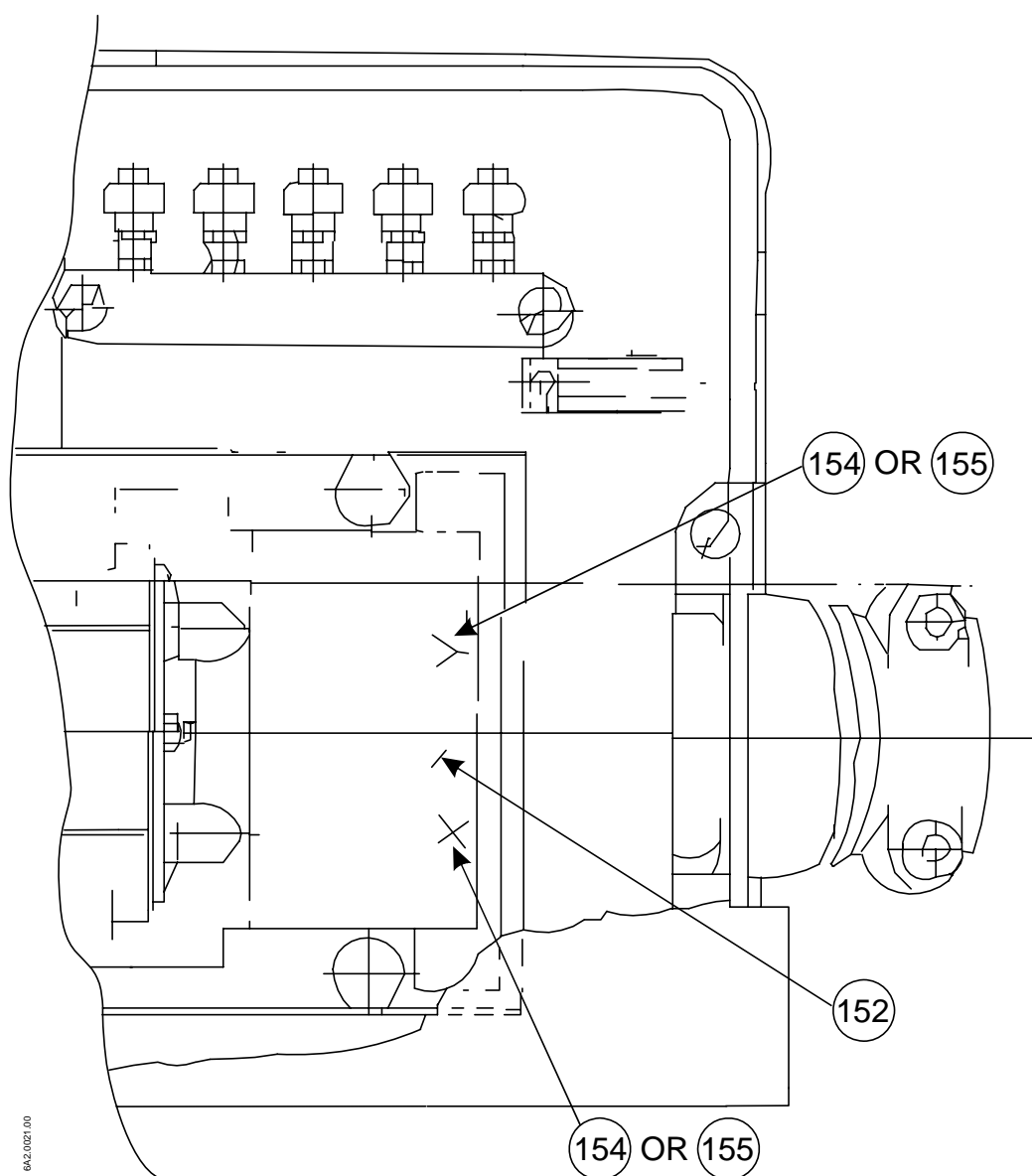


Figure 7-5. Contactor Assembly (N451161-5303) “X” and “Y” Label Location

**7.5. Contactor Assembly (N410011-01)**

Machines manufactured beginning October 2005 use contactor N410011-01. Machines manufactured before October 2005 use contactor N451161-5303 (see Section 7.4).

Table 7–5. Contactor Assembly (N410011-01) Parts List

Item	Description	Part Number
05	Contactor Mounting Plate	M410010-01
10	Contactor, Four-Pole, 125 VDC	J709599-0008
15	Contactor Bracket, Left-Hand	M410008-01
20	Contactor Bracket, Right-Hand	M410008-02
25	Screw, #8-32 x 1/2" Hex Socket Head SS	J500124-0032
30	Washer, #8 Lock, Steel, M1060 75	J047681
35	Washer, #8 Plate, SST	J475120-0109
40	Bolt, Contactor Shoulder	M410012-01
45	Washer, 1/4" Plate, SST	J475120-0112
50	Nut, 1/4"-20 Elastic, SS	J480325
55	Clamp, Harness	J703005
60	Screw, 1/4-20 x 5/8" Cap, SS	J500097-0110
65	Washer, 1/4" Lock, SST	J475121-0111
70	Tag Self Adhesive "X"	J075827-0001
75	Tag Self Adhesive "Y"	J075827-0002
80	Jumper, Contactor	N451161-5802
85	Interlock, #LADT9R1	J709599-0009
90	Washer, 5/16" Plate, SST	J475120-0113
95	Tubing, Heat Shrink, 3/8"	A774242-0017
100	Tape, 0.002 x 2", Kapton	A773716

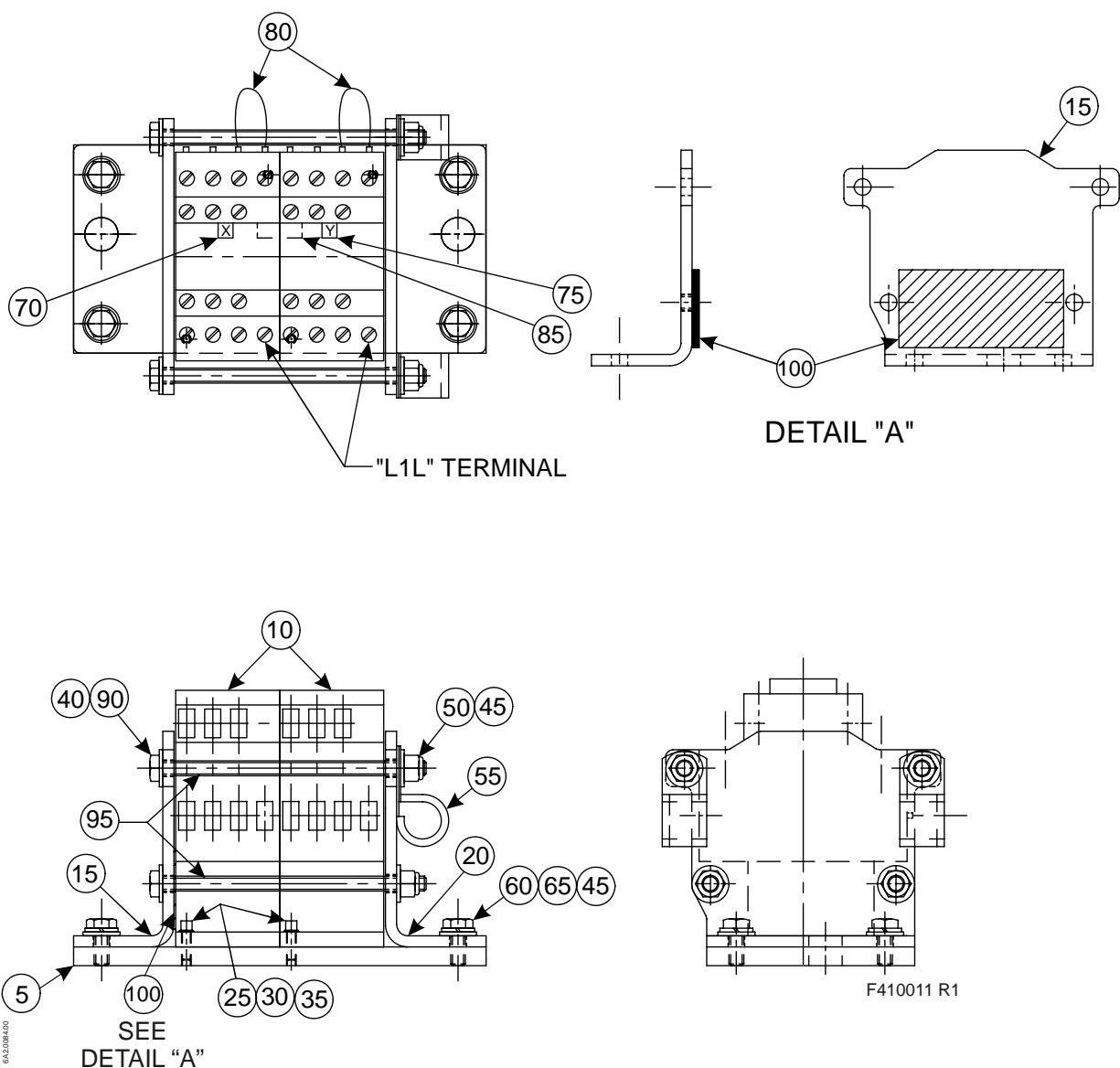


Figure 7-6. Contactor Assembly (N410011-01) Parts Location

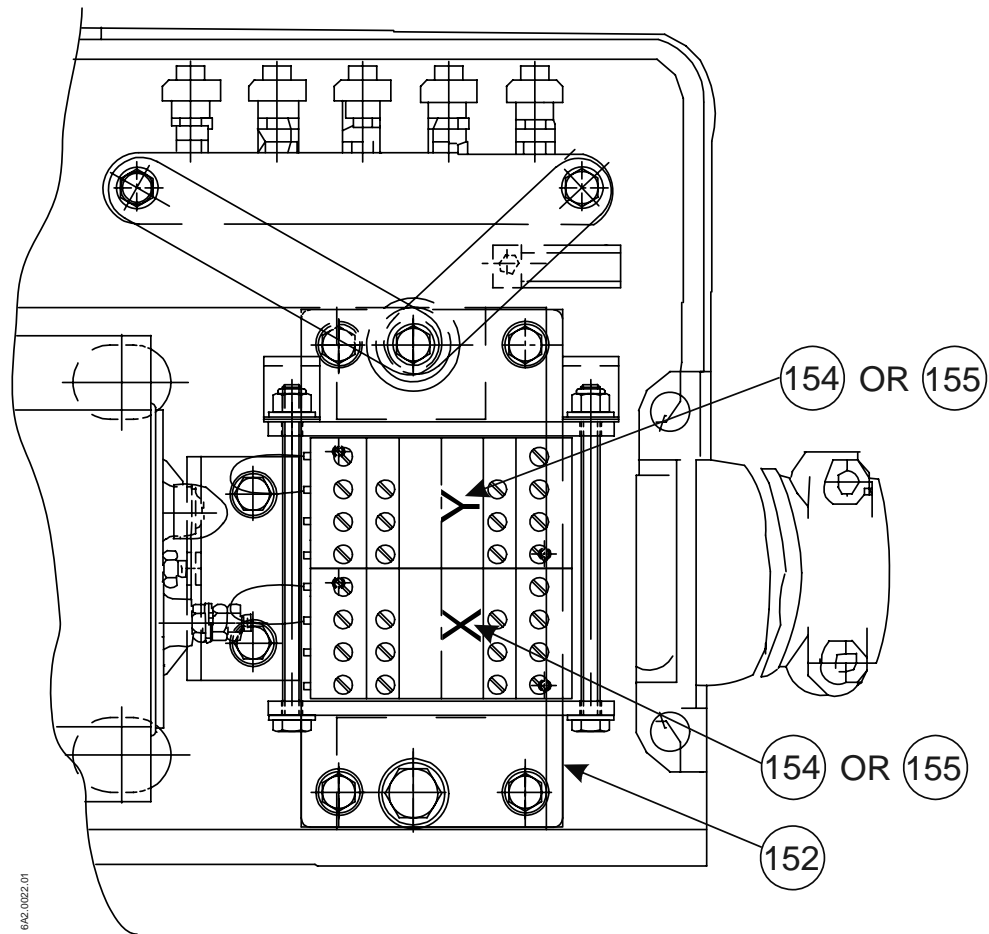


Figure 7-7. Contactor Assembly (N410011-01) “X” and “Y” Label Location

7.6. Motor Assembly

Table 7-6. Motor Assembly (N451161-1706) Parts List

Item	Description	Part Number
05	Motor Frame	M451161-5501
10	Motor-Electric 110 VDC	M451161-5701
15	Adaptor Plate	M451161-1101
20	Screw, 5/16-18 x 1" Flat Hd., Allen	J500124-0001
25	Screw, 3/8-16 x 1" Flat Hd., Allen	J500124-0002
30	Gear	M451161-1601
35	Key	M451161-1305
40	Screw, 10-32 x 1/4" Allen Hd.	J507363
45	Snap Ring, External Retaining	J792852
50	Cap Protective, 0.531" Dia.	J703489
55	Screw, 10-32 x 1/2" Brass.	M451358-3208
60	Washer, 17/64 x 9/16" Copper	J047818
65	Washer, Lock, 5/16" Countersunk	J475143-0001
70	Washer, Lock, 3/8" Countersunk	J475143-0002
75	Cable Grip, 1/2"	J712108-0001
80	Nut, Lock, 1/2"	J048414
85	Bushing, 7/8 x 1-3/8"	J079994
90	Not Used	Not Applicable
95	Not Used	Not Applicable
100	Bracket, Motor Support	M410009-03
105	Nut, Motor Support	M410009-02
110	Screw, 1/4-20 x 1"	J500097-0116
115	Washer, 1/4" Plate	J475120-0112
120	Washer, 1/4" Lock	J475121-0111
121	Brush Kit	J064205-0004
122	Brush Spring Kit	J680206

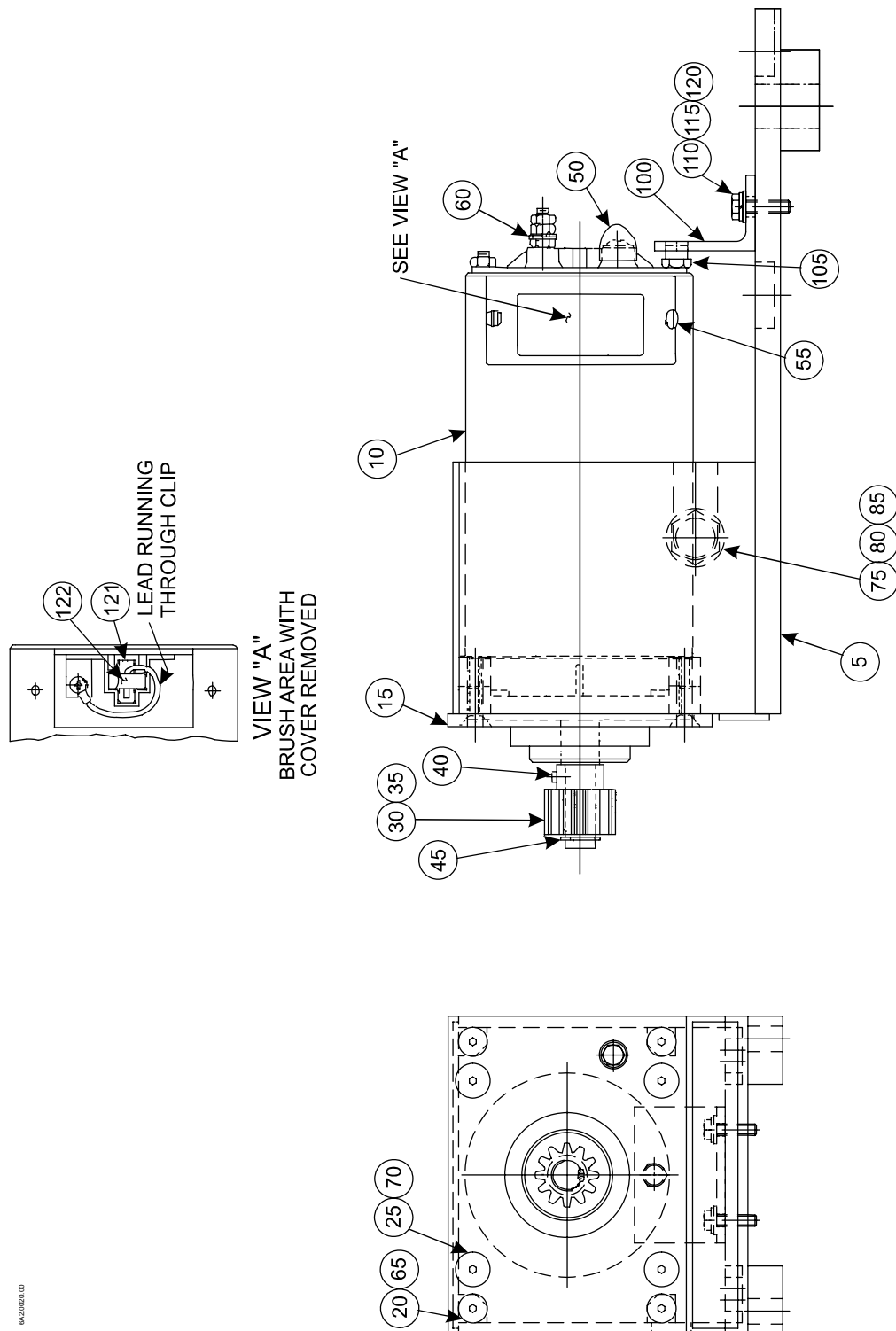


Figure 7-8. Motor Assembly (N451161-1706) Parts Location



8. RAIL TEAM AND TECHNICAL SUPPORT

The Rapid Action Information Link Team (RAIL Team) is a group of experienced product and application engineers ready to assist you to resolve any technical issues concerning this product. Contact the RAIL Team in the United States at 1-800-652-7276 or by e-mail at railteam@ansaldo-sts.us.





End of Manual